DaqBoard/3000USB Series User's Manual

USB 1-MHz, 16-Bit Data Acquisition Boards

A Hardware Reference Manual for:

DaqBoard/3001USB
DaqBoard/3005USB
DaqBoard/3031USB
DaqBoard/3035USB

Requires one of the following Operating Systems:

Windows 2000
Windows XP

IOtech, Inc.
25971 Cannon Road
Cleveland, OH 44146-1833
Phone: (440) 439-4091
Fax: (440) 439-4093
E-mail (Product Information): sales@iotech.com
E-mail (Technical Support): productsupport@iotech.com
Internet: www.iotech.com

DaqBoard/3000USB Series
User's Manual

USB 1-MHz, 16-Bit
Data Acquisition Boards

p/n 1136-0902 Rev. 3.0

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Phone: (440) 439-4091, fax: (440) 439-4093, e-mail: sales@iotech.com

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This warning symbol is used in this manual or on the equipment to warn of possible injury or death from electrical shock under noted conditions.

This ESD caution symbol urges proper handling of equipment or components sensitive to damage from electrostatic discharge. Proper handling guidelines include the use of grounded anti-static mats and wrist straps, ESD-protective bags and cartons, and related procedures.

This symbol indicates the message is important, but is not of a Warning or Caution category. These notes can be of great benefit to the user, and should be read.

In this manual, the book symbol always precedes the words "Reference Note." This type of note identifies the location of additional information that may prove helpful. References may be made to other chapters or other documentation.

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Specifications and Calibration

Specifications are subject to change without notice. Significant changes will be addressed in an addendum or revision to the manual. As applicable, IOtech calibrates its hardware to published specifications. Periodic hardware calibration is not covered under the warranty and must be performed by qualified personnel as specified in this manual. Improper calibration procedures may void the warranty.

Quality Notice

IOtech has been an ISO 9001 registered firm since 1996. Prior to shipment, we thoroughly test our products and review our documentation to assure the highest quality in all aspects. In a spirit of continuous improvement, IOtech welcomes your suggestions.

Your order was carefully inspected prior to shipment. When you receive your system, carefully unpack all items from the shipping carton and check for physical signs of damage that may have occurred during shipment. Promptly report any damage to the shipping agent and your sales representative. Retain all shipping materials in case the unit needs returned to the factory.

CAUTION

Using this equipment in ways other than described in this manual can cause personal injury or equipment damage. Before setting up and using your equipment, you should read *all* documentation that covers your system. Pay special attention to Warnings and Cautions.

Note: During software installation, Adobe® PDF versions of user manuals will automatically install onto your hard drive as a part of product support. The default location is in the **Programs** group, which can be accessed from the *Windows Desktop*. Initial navigation is as follows:

Start [Desktop "Start" pull-down menu]
⇒ **Programs**
⇒ **IOtech DaqX Software**

You can also access the PDF documents directly from the data acquisition CD by using the <**View PDFs**> button located on the opening screen.

Refer to the PDF documentation for details regarding both hardware and software.

A copy of the Adobe Acrobat Reader® is included on your CD. The Reader provides a means of reading and printing the PDF documents. Note that hardcopy versions of the manuals can be ordered from the factory.

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DaqBoard/3000USB Series Installation Guide

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p/n **1136-0941** Rev. **2.0**

DaqBoard/3000USB Series Installation Guide

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Reference Note:
After you have completed the installation you should refer to the electronic documents that were automatically installed onto your hard drive as a part of product support. The default location is in the **Programs** group, which can be accessed from the Windows Desktop.

You should keep your DaqBoard/3000USB serial number and board type, e.g., 3001USB, 3005USB, etc., as well as any authorization codes (if applicable) with this document. Space is provided below for recording up to 4 board numbers. Board serial numbers and board types are clearly visible on the boards.

	Board Type	Serial Number
Board 1		
Board 2		

Board Type		Serial Number
Board 3		
Board 4		

CAUTION

Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.)

Use care to avoid touching board surfaces and onboard components. Only handle boards by their edges (or ORBs, if applicable). Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.

Reference Note: Adobe PDF versions of user manuals will automatically install onto your hard drive as a part of product support.** The default location is in the **Programs** group, which can be accessed from the *Windows Desktop*. Refer to the PDF documentation for details regarding both hardware and software. Note that hardcopy versions of the manuals can be ordered from the factory.

** Manuals can also be read directly from the data acquisition CD via the View PDFs option on the splash screen, or from our web site.

Minimum System Requirements

Pentium® P3 Processor, 500 MHz
Windows Operating System
RAM: 128 Mbytes
USB Port*

* USB2.0 Recommended

Power Consumption (per board):

Model	**Power Consumption** (Typical)*	**TR-2 Power Adapter***
/3001USB	3000 mW	Required
/3005USB	2000 mW	Optional
/3031USB	3400 mW	Required
/3035USB	2400 mW	Recommended

*A power adapter (TR-2) will be required if the USB port cannot supply adequate power. USB2 ports are, by USB2 standards, required to supply 2500 mW (nominal at 5V, 500 mA).

(1) Install Software

IMPORTANT: Software must be installed before installing hardware.

(a) Place the Data Acquisition CD into the CD-ROM drive. *Wait for PC to auto-run the CD. This may take a few moments, depending on your PC.* If the CD does not auto-run, use the Desktop's Start/Run/Browse feature and run the **Setup.exe** file.

(b) After the intro-screen appears, follow the screen prompts.

(c) After successful installation turn off the computer and proceed with the following section, *Connect Signal Lines and Hardware*.

(2) Connect Signal Lines and Hardware

This section presents three examples of hardware setup. Other scenarios are possible, for example, using a TB-100 and also using one CA-248 cable. Also note that a TR-2 power supply will be needed when there is insufficient power from the USB port. However, you can use a TR-2 in any scenario.

Aside from using a TR-2, if needed, another important part of the setup is to avoid making redundant signal connections and to use approved ESD precautions. Pinouts have been included in this installation guide.

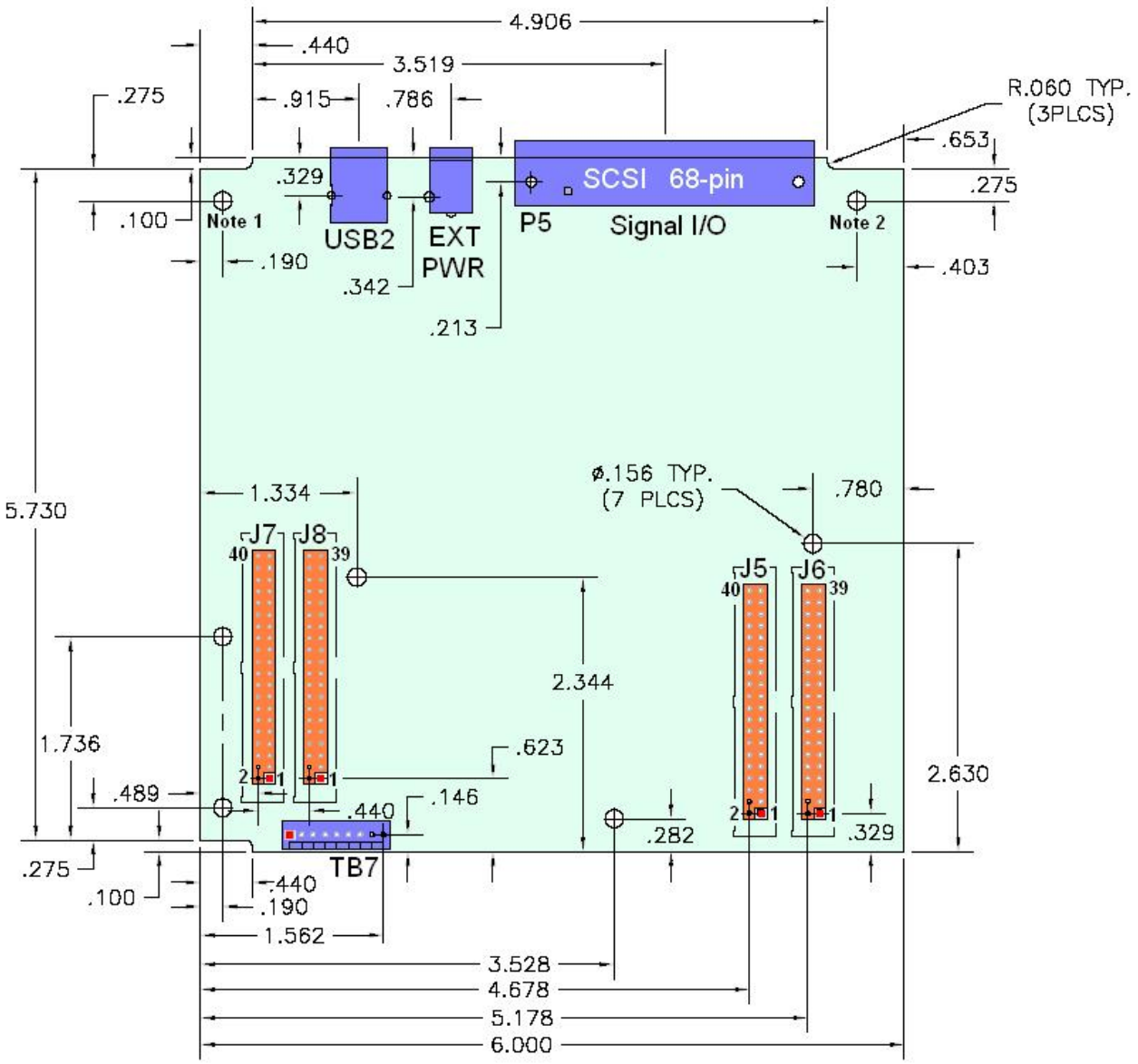
CAUTION

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage. You should always handle components carefully, and you should never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD controlled area. Such guidelines include the use of properly grounded mats and wrist straps, ESD bags and cartons, and related procedures.

The "Power" LED **(Bottom LED)** blinks during device detection and initialization; then remains on solid as long as the module has power. If there is insufficient power the LED will go off and a TR-2 power adapter will be needed.

Note that when the board is first powered there will likely be a momentary delay before the Power LED begins to blink, or come on solid.

If using a TR-2, be sure to supply power from it to the DaqBoard/3000USB Series board before connecting the USB cable to the computer. This allows the USB board to inform the host computer (upon connection of the USB cable) that the unit requires minimal power from the computer's USB port.



DaqBoard/3000USB Series – Board Dimensions

In general, all standoffs should be used to mount the board to a metal frame.

Note 1: The standoff at this location connects to the USB chassis for shunting electrostatic discharge.

Note 2: The standoff at this location connects to the DaqBoard/3000USB board's internal chassis plane for shunting electrostatic discharge.

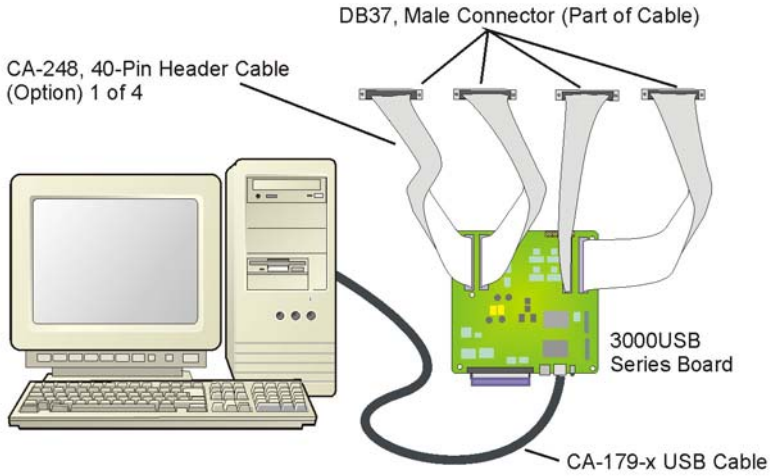
WARNING !

Avoid redundant connections. Ensure there is no signal conflict between SCSI pins and the associated header pin (J5. J6. J7. and J8). Also ensure there is no conflict between TB7 (thermocouple connections) and the SCSI and/or the 40-pin headers. Failure to do so could possibly cause equipment damage and/or personal injury.

WARNING !

Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

Scenario 1: Using CA-248 Cables to obtain DB37 Connectors



In this setup a CA-248 cable is connected to each of the 40-pin headers (J5, J6, J7, and J8). The result is four male DB37 connectors which, as can be seen from the pinouts, offer the same signal connectivity as the SCSI connector. Note that the J6 header is dedicated entirely to analog expansion and therefore is not applicable to /3001USB or /3005USB. As in all scenarios, **a CA-179-x USB cable is used to connect the /3000USB Series board to a USB port on the host PC**. USB2.0 is recommended.

If you need to find the name of your device, for example, if you are writing a custom program for multiple devices, navigate from the Windows Desktop to the Device Manager. The navigation path is:

Start⇨Settings⇨Control Panel⇨System⇨Hardware(Tab) ⇨Device Manager⇨Daqx PnP Devices

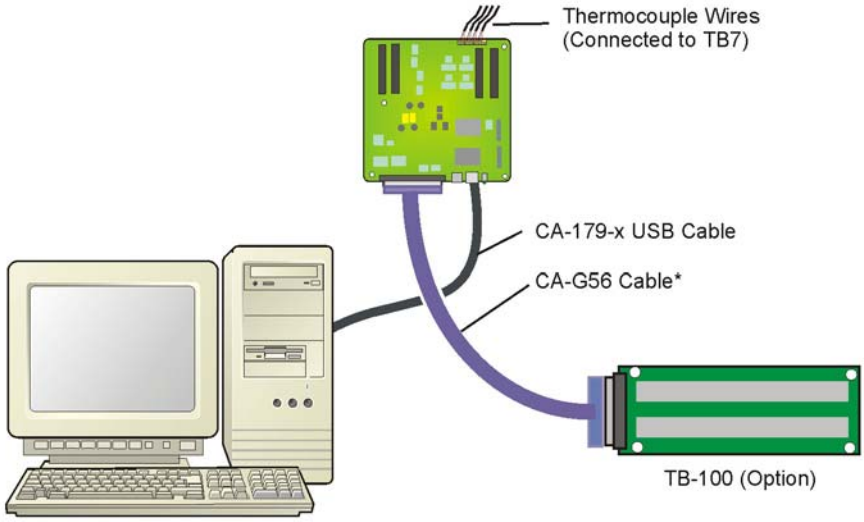
You will see the device listed in the format of DaqBoard/3000USB (see first figure, below).

You can change the name of the device by doing a *right-click* on the device name to open its properties dialog box, then clicking on the Properties tab (see second figure). You can then change the "FriendlyName" of the device.

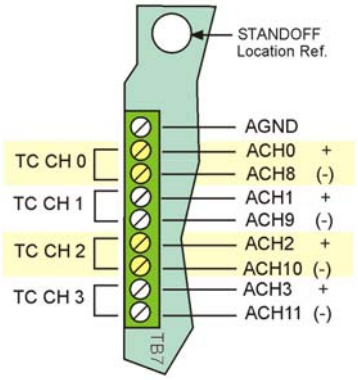
Locating DaqXPnP Devices

Properties Dialog Box

Scenario 2: Using a TB-100



In this setup a TB-100 screw-terminal board option is connected to the 68-pin SCSI connector via a CA-G56 shielded cable. However, the use of other cables is possible as noted below. In this example we can also see that 4 thermocouples are connected at TB7 (on the /3000USB board). This means that 8 analog channels [to obtain 4 differential TC channels] are required (see following figure). Redundant connections must be avoided. **A CA-179-x USB cable is used to connect the /3000USB Series board to a USB port on the host PC**. USB2.0 is recommended.



WARNING !

Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The TB7 terminal block can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

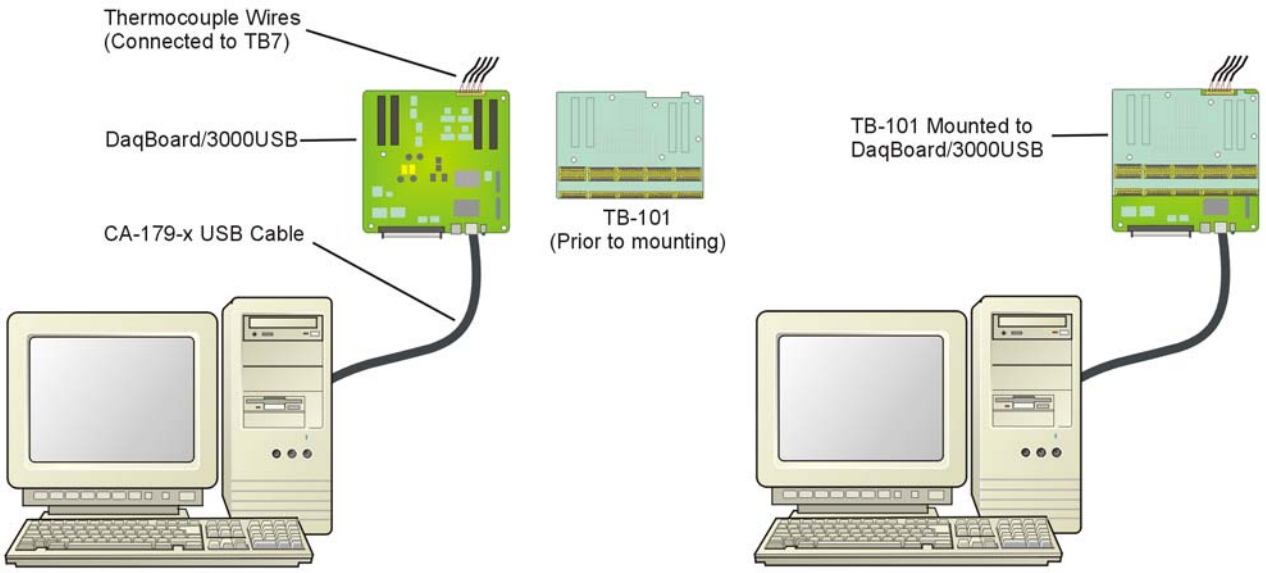
In DaqBoard/3000USB Series applications, thermocouples should only be connected in differential mode. Connecting thermocouples in single-ended mode can cause noise and false readings. Appendix B of the user's manual includes additional information.

As in all scenarios, a CA-179-x USB cable is used to connect the /3000USB Series board to a USB2.0 port on the host PC.

* Any of the following 68-conductor expansion cables can be used to connect the TB-100 option the SCSI connector:

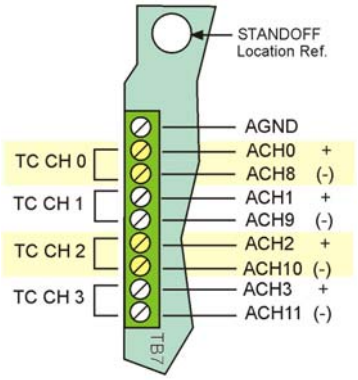
CA-G55	3 feet, ribbon cable.
CA-G56	3 feet, shielded expansion cable.
CA-G56-6	6 feet, shielded expansion cable.

Scenario 3: Using a TB-101 Terminal Board Option



In this setup a TB-101 terminal board is plugged directly into the 40-pin headers (J5, J6, J7, and J8) of the main board. No cables are used in making this connection. "Stand-offs" are used to keep the boards from touching (instructions are provided on the following page).

In this example 4 thermocouples are connected at TB7 (on the /3000USB board). This means that 8 analog channels [to obtain 4 differential TC channels] are required (see following figure). Redundant connections must be avoided.



WARNING !

Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

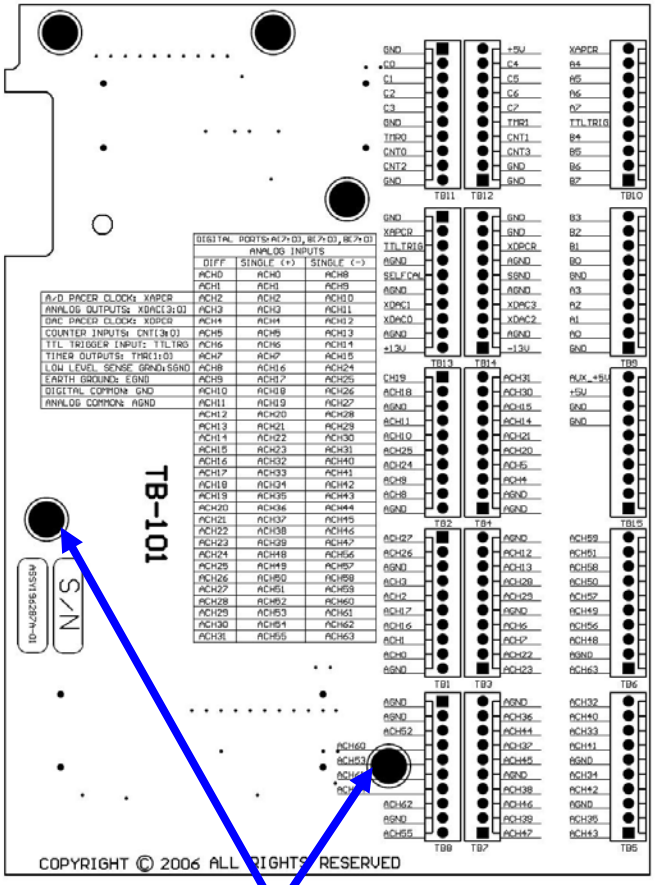
The TB7 terminal block [on the DaqBoard/3000USB] can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

In DaqBoard/3000USB Series applications, thermocouples should only be connected in differential mode. Connecting thermocouples in single-ended mode can cause noise and false readings. Appendix B of the user's manual includes additional information.

A CA-179-x USB cable is used to connect the /3000USB Series board to a USB port on the host PC. USB2.0 is recommended.

CAUTION

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage. You should always handle components carefully, and you should never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD controlled area. Such guidelines include the use of properly grounded mats and wrist straps, ESD bags and cartons, and related procedures.



Standoff Locations, 5 in Total

How to Mount the TB-101

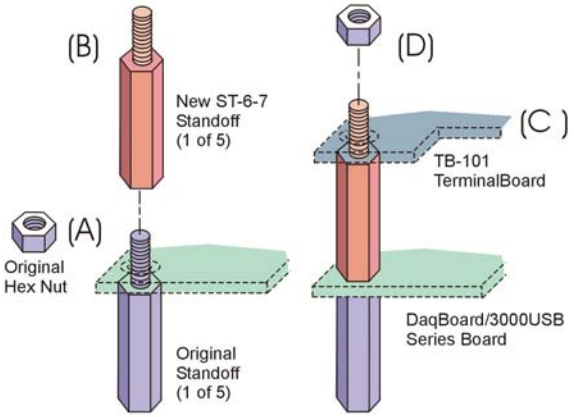
(Steps A through D refer to the following illustration)

A – After taking ESD precautions, remove the Hex Nuts from the 5 existing standoffs.

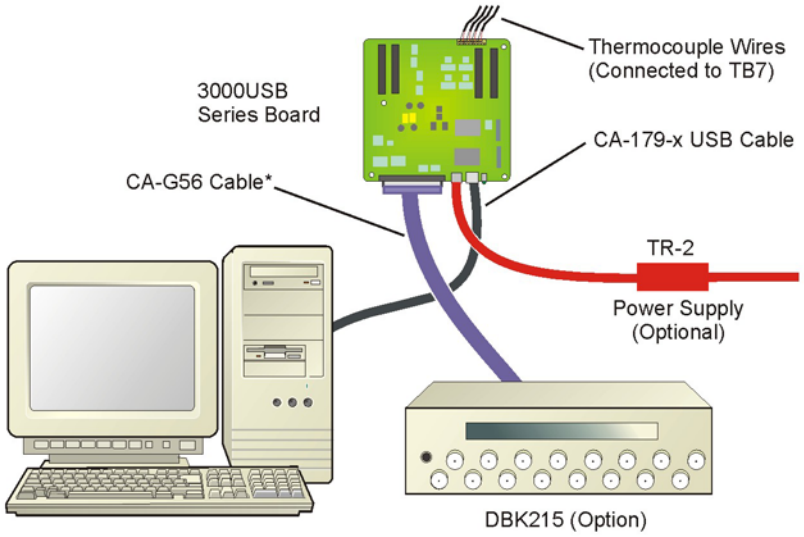
B – Thread the new ST-6-7 standoffs onto the existing standoffs. Tighten snug by hand.

C – Align the TB-101 with the new standoffs and position the board in place.

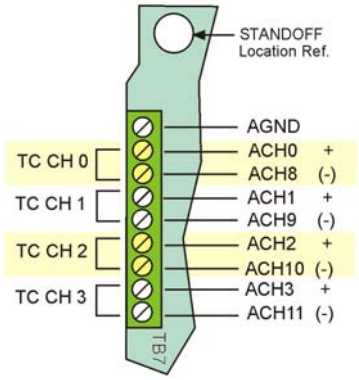
D – Using the Hex Nuts (removed in Step A), secure the TB-101 to the new standoffs. Tighten snug. Over-tighten will damage the board.



Scenario 4: Using a DBK215



In this setup a DBK215 BNC Module is connected to the 68-pin SCSI connector via a CA-G56 shielded cable. However, the use of other cables is possible as noted below. In this example we can also see that 4 thermocouples are connected at TB7 (on the /3000USB board). This means that 8 analog channels [to obtain 4 differential TC channels] are required (see following figure). Redundant connections must be avoided. A TR-2 power supply is being used, and is connected to the board's external power connector. **A CA-179-x USB cable is used to connect the /3000USB Series board to a USB port on the host PC**. USB2.0 is recommended.



WARNING !

Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The TB7 terminal block can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

In DaqBoard/3000USB Series applications, thermocouples should only be connected in differential mode. Connecting thermocouples in single-ended mode can cause noise and false readings. Appendix B of the user's manual includes additional information.

As in all scenarios, a CA-179-x USB cable is used to connect the /3000USB Series board to a USB2.0 port on the host PC.

* Any of the following 68-conductor expansion cables can be used to connect the DBK215 module option the SCSI connector:

CA-G55	3 feet, ribbon cable.
CA-G56	3 feet, shielded expansion cable.
CA-G56-6	6 feet, shielded expansion cable.

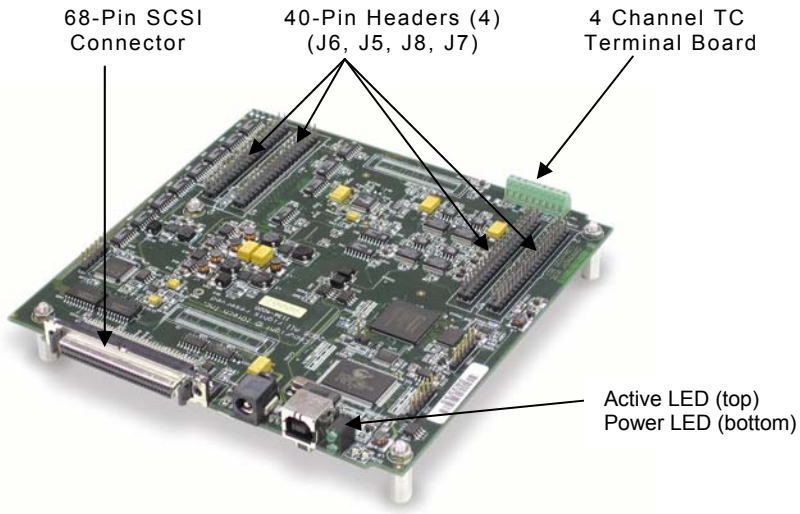
WARNING !

Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

CAUTION

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage. You should always handle components carefully, and you should never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD controlled area. Such guidelines include the use of properly grounded mats and wrist straps, ESD bags and cartons, and related procedures.

DaqBoard/3031USB and DaqBoard/3035USB make use of J5 and J6 (two of the four 40-pin headers) for analog expansion. Pinouts for these and the remaining two headers (J7 and J8) are included in this section. A pinout for a 4-channel terminal board (TB7) is also included.



Locations of Signal Connectors and LEDs

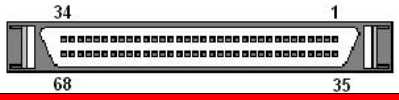
LEDs: DaqBoard/3000USB Series boards have 2 LEDs located just right of the USB2 connector (see figure). The LEDs function as follows:

Active LED **(Top LED)**
This LED is on whenever active USB communication is taking place between the DaqBoard and the host PC. Note that the Active LED will be on solid during a data acquisition.

Power LED **(Bottom LED)**
The "Power" LED blinks during device detection and initialization; then remains on solid as long as the module has power. If there is insufficient power the LED will go off and a TR-2 power adapter will be needed.

Note that when the board is first powered there will likely be a momentary delay before the Power LED begins to blink, or come on solid.

68-Pin SCSI Connecter



WARNING !

Avoid redundant connections. Ensure there is no signal conflict between SCSI pins and the associated header pin (J5. J6. J7. and J8). Also ensure there is no conflict between TB7 (thermocouple connections) and the SCSI and/or the 40-pin headers. Failure to do so could possibly cause equipment damage and/or personal injury.

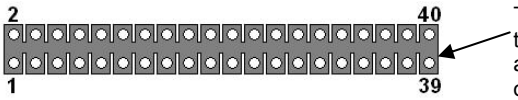
Pin numbers refer to the 68-pin SCSI female connector, located on the DaqBoard.

Function		Pin		Pin	Function	
Analog input Channel 8		34		68	Analog input Channel 0	
Analog input Channel 1		33		67	Analog Common	
Analog Common		32		66	Analog input Channel 9	
Analog input Channel 10		31		65	Analog input Channel 2	
Analog input Channel 3		30		64	Analog Common	
Analog Common		29		63	Analog input Channel 11	
Analog input Channel 4		28		62	Low Level Sense Common	
Analog Common		27		61	Analog input Channel 12	
Analog input Channel 13		26		60	Analog input Channel 5	
Analog input Channel 6		25		59	Analog Common	
Analog Common		24		58	Analog input Channel 14	
Analog input Channel 15		23		57	Analog input Channel 7	
Analog Output 0 (**DAC0**) Note 1		22		56	Analog Output 3 (**DAC3**) Note 1	
Analog Output 1 (**DAC1**) Note 1		21		55	Analog Output 2 (**DAC2**) Note 1	
SELFCAL		20		54	Digital Common	
Vcc (+5 VDC)		19		53	Digital Common	
Digital I/O line A0	**PORT A**	18		52	Digital I/O line A1	**PORT A**
Digital I/O line A2		17		51	Digital I/O line A3	
Digital I/O line A4		16		50	Digital I/O line A5	
Digital I/O line A6		15		49	Digital I/O line A7	
Digital I/O line B0	**PORT B**	14		48	Digital I/O line B1	**PORT B**
Digital I/O line B2		13		47	Digital I/O line B3	
Digital I/O line B4		12		46	Digital I/O line B5	
Digital I/O line B6		11		45	Digital I/O line B7	
Digital I/O line C0	**PORT C**	10		44	Digital I/O line C1	**PORT C**
Digital I/O line C2		9		43	Digital I/O line C3	
Digital I/O line C4		8		42	Digital I/O line C5	
Digital I/O line C6		7		41	Digital I/O line C7	
TTL Trigger Input		6		40	Digital Common	
Counter Input CTR0		5		39	Counter Input CTR1	
Counter Input CTR2		4		38	Counter Input CTR3	
Timer Output 0		3		37	Timer Output 1	
A/D Pacer Clock Input/Output		2		36	Digital Common	
DAC Pacer Clock I/O		1		35	Digital Common	

Note 1: DaqBoard/3001USB and /3031USB each include DAC0, DAC1, DAC2, and DAC3. DaqBoard/3005USB and /3035USB have no DACs.

J5 and J6, 40-Pin Headers for Analog Channels

Note: All channels are available for DaqBoard/3031USB and /3035USB. Channels 16 through 63 are not available for DaqBoard/3001USB and /3005USB.



This edge of the header is closest to the board's center. Note that pins 2 and 40 are labeled on the board overlay.

Each 40-pin header can be terminated out to a DB37 male connector via the CA-248 cable.

J5

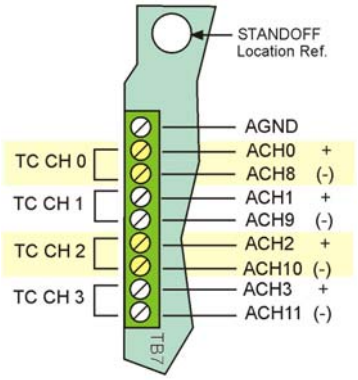
Analog CH.	Pin	Pin	Analog CH.
CH 27	1	2	CH 19
CH 26	3	4	CH 18
Analog Com.	5	6	Analog Com.
CH 3 ⚠	7	8	CH 11 ⚠
CH 2 ⚠	9	10	CH 10 ⚠
CH 17	11	12	CH 25
CH 16	13	14	CH 24
CH 1 ⚠	15	16	CH 9 ⚠
CH 0 ⚠	17	18	CH 8 ⚠
Analog Com.	19	20	Analog Com.
CH 23	21	22	CH 31
CH 22	23	24	CH 30
CH 7	25	26	CH 15
CH 6	27	28	CH 14
Analog Com.	29	30	CH 21
CH 29	31	32	CH 20
CH 28	33	34	CH 5
CH 13	35	36	CH 4
CH 12	37	38	Analog Com.
Analog Com.	39	40	Analog Com.

J6

Analog CH.	Pin	Pin	Analog CH.
CH 43	1	2	CH 59
CH 35	3	4	CH 51
Analog Com.	5	6	CH 58
CH 42	7	8	CH 50
CH 34	9	10	CH 57
Analog Com.	11	12	CH 49
CH 41	13	14	CH 56
CH 33	15	16	CH 48
CH 40	17	18	Analog Com.
CH 32	19	20	CH 63
CH 47	21	22	CH 55
CH 39	23	24	Analog Com.
CH 46	25	26	CH 62
CH 38	27	28	CH 54
Analog Com.	29	30	CH 61
CH 45	31	32	CH 53
CH 37	33	34	CH 60
CH 44	35	36	CH 52
CH 36	37	38	Analog Com.
Analog Com.	39	40	Analog Com.

⚠ **For Analog Channels 0, 1, 2, 3, 8, 9, 10, and 11: Read the following WARNING which applies to their use as thermocouple channels.**

TB7, 4-Channel Thermocouple Terminal Block



WARNING !

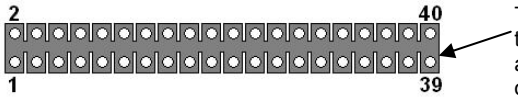
Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The TB7 terminal block can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

J7 and J8, 40-Pin Headers for

Digital Ports, Counters, Timers, DACS, Triggers, Pacer Clocks and Other Signals

Note: The 4 DAC channels are available for DaqBoard/3001USB and /3031USB. The DACs do not apply to DaqBoard/3005USB and /3035USB.



This edge of the header is closest to the board's center. Note that pins 2 and 40 are labeled on the board overlay.

Each 40-pin header can be terminated out to a DB37 male connector via the CA-248 cable.

J7

Digital CH.		Pin	Pin		Digital CH.
Digital GND		1	2		XAPCR *
PORT A	CH A0	3	4		CH A4
	CH A1	5	6		CH A5
	CH A2	7	8		CH A6
	CH A3	9	10		CH A7
Digital GND		11	12		XTTLTRG
PORT B	CH B0	13	14		CH B4
	CH B1	15	16		CH B5
	CH B2	17	18		CH B6
	CH B3	19	20		CH B7
Digital GND		21	22		Exp +5 Volts
PORT C	CH C0	23	24		CH C4
	CH C1	25	26		CH C5
	CH C2	27	28		CH C6
	CH C3	29	30		CH C7
Digital GND		31	32		Timer 1
Timer 0		33	34		Counter 1
Counter 0		35	36		Counter 3
Counter 2		37	38		Digital GND
Digital GND		39	40		Digital GND

* XAPCR = A/D Pacer Clock I/O

J8

Signal	Pin	Pin	Signal
+13VA	1	2	-13VA
--X--	3	4	--X--
Analog Com.	5	6	Analog Com.
XDAC0	7	8	XDAC2
XDAC1	9	10	XDAC3
Analog Com.	11	12	Analog Com.
SelfCal	13	14	SGND **
Analog Com.	15	16	Analog Com.
XTTLTRG	17	18	XDPCR ***
XAPCR*	19	20	Digital GND
Digital GND	21	22	Digital GND
--X--	23	24	--X--
Exp. +5 Volts	25	26	Aux Pwr
--X--	27	28	--X--
--X--	29	30	--X--
--X--	31	32	--X--
--X--	33	34	--X--
--X--	35	36	--X--
--X--	37	38	--X--
--X--	39	40	--X--

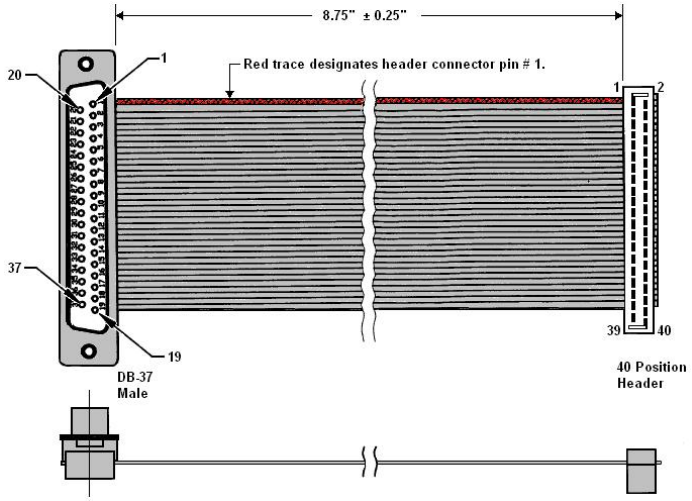
-- *X*-- = Not Connected

** SGND = Signal Ground (Low Level Sense Common)
*** XDPCR = DAC Pacer Clock I/O

Reference Note:
The DaqBoard/3000USB Series Users Manual (p/n 1136-0902) includes a pinout for the TB-100 screw-terminal board connector option. It also includes an appendix pertaining to the DBK215 16-BNC Connector Module. A PDF version of the manual is included on the data acquisition CD and is also installed on your PC in the DaqView program group which can be accessed from your Windows' Desktop Start Menu.*

*Default location.

CA-248, 40-Position Header to DB-37 Male, Ribbon Cable



CA-248 Pinout, DB-37 Pins listed Sequentially

DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.
1	1		11	21		21	4		31	24
2	3		12	23		22	6		32	26
3	5		13	25		23	8		33	28
4	7		14	27		24	10		34	30
5	9		15	29		25	12		35	32
6	11		16	31		26	14		36	34
7	13		17	33		27	16		37	36
8	15		18	35		28	18		---	---
9	17		19	37		29	20		---	---
10	19		20	2		30	22		---	---

CA-248 Pinout, 40 Position Header Pins listed Sequentially

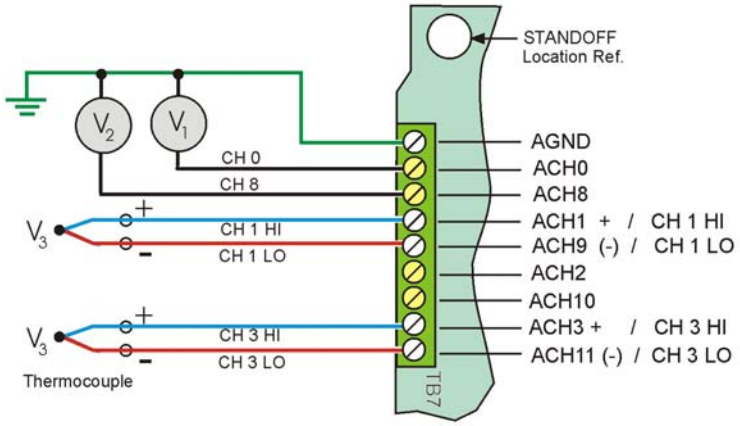
DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.
1	1		6	11		11	21		16	31
20	2		25	12		30	22		35	32
2	3		7	13		12	23		17	33
21	4		26	14		31	24		36	34
3	5		8	15		13	25		18	35
22	6		27	16		32	26		37	36
4	7		9	17		14	27		19	37
23	8		28	18		33	28		---	38
5	9		10	19		15	29		---	39
24	10		29	20		34	30		---	40

Connecting Thermocouple Wires

In DaqBoard/3000USB applications, thermocouples must be connected *differentially*. Failure to do so will result in false readings.

Differential connection is made as follows:

(a) the red wire connects to the channel's Low (L) connector.
(b) the second [color-coded] wire connects to the channel's High (H) connector.



Single-Ended and Differential Connections to TB7

The figure shows voltage Single-ended connections for V1 (Channel 0) and V2 (Channel 8); it also shows V3 and V4, each resulting from a different thermocouple. In the case of V3 and V4, *Differential* mode is being used. The HI (+) line from the thermocouple is shown connected to Channel 1 HI; and the LO (negative) side is connected to Channel 1 LO. Notice that Channel 1 LO is the same screw terminal connection that would be used for CH 9 Single-Ended. V4 is connected in a similar manner (see figure).

In DaqBoard/3000USB applications, thermocouples should only be connected in differential mode. Connecting thermocouples in single-ended mode can cause noise and false readings. Appendix B of the user's manual includes additional information.

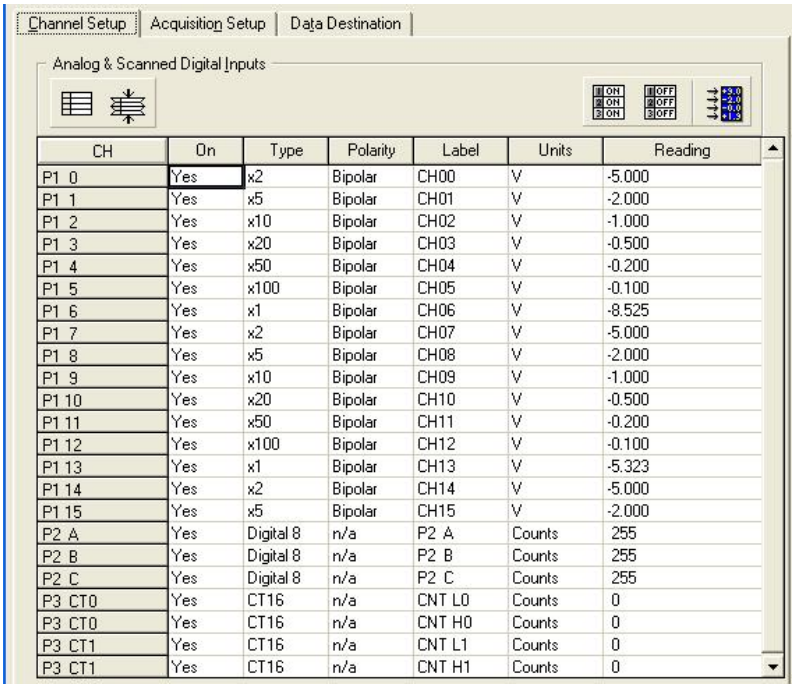
(3) Start DaqView

From Windows, open DaqView by double clicking on its icon, or use the Windows Desktop Start menu to access the program. You will find *DaqView* listed in the **Program** group (Use the desktop Start Menu / Programs to access the group).

Once the program is executed, software automatically identifies your Personal Daq/3000 Series device and brings up DaqView's *Main Window*. This window is discussed briefly in the following text, and in more detail in the *DaqView Manual* PDF included on the installation CD.

(4) Configure the System

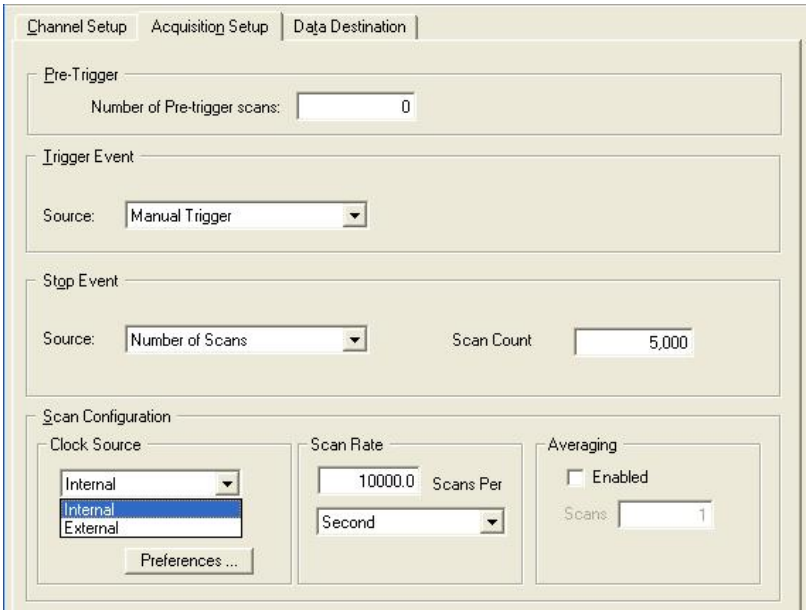
The Channel Setup window (first tab on lower portion of main window) displays the analog and scanned digital input channels and allows you to configure them.



CH	On	Type	Polarity	Label	Units	Reading
P1 0	Yes	x2	Bipolar	CH00	V	-5.000
P1 1	Yes	x5	Bipolar	CH01	V	-2.000
P1 2	Yes	x10	Bipolar	CH02	V	-1.000
P1 3	Yes	x20	Bipolar	CH03	V	-0.500
P1 4	Yes	x50	Bipolar	CH04	V	-0.200
P1 5	Yes	x100	Bipolar	CH05	V	-0.100
P1 6	Yes	x1	Bipolar	CH06	V	-8.525
P1 7	Yes	x2	Bipolar	CH07	V	-5.000
P1 8	Yes	x5	Bipolar	CH08	V	-2.000
P1 9	Yes	x10	Bipolar	CH09	V	-1.000
P1 10	Yes	x20	Bipolar	CH10	V	-0.500
P1 11	Yes	x50	Bipolar	CH11	V	-0.200
P1 12	Yes	x100	Bipolar	CH12	V	-0.100
P1 13	Yes	x1	Bipolar	CH13	V	-5.323
P1 14	Yes	x2	Bipolar	CH14	V	-5.000
P1 15	Yes	x5	Bipolar	CH15	V	-2.000
P2 A	Yes	Digital 8	n/a	P2 A	Counts	255
P2 B	Yes	Digital 8	n/a	P2 B	Counts	255
P2 C	Yes	Digital 8	n/a	P2 C	Counts	255
P3 CT0	Yes	CT16	n/a	CNT L0	Counts	0
P3 CT0	Yes	CT16	n/a	CNT H0	Counts	0
P3 CT1	Yes	CT16	n/a	CNT L1	Counts	0
P3 CT1	Yes	CT16	n/a	CNT H1	Counts	0

Channel Setup Tab Selected

Selecting the second tab of the main window displays the Acquisition Setup window, used to set triggering and configure the scan. These settings will be used when an acquisition to disk is started.

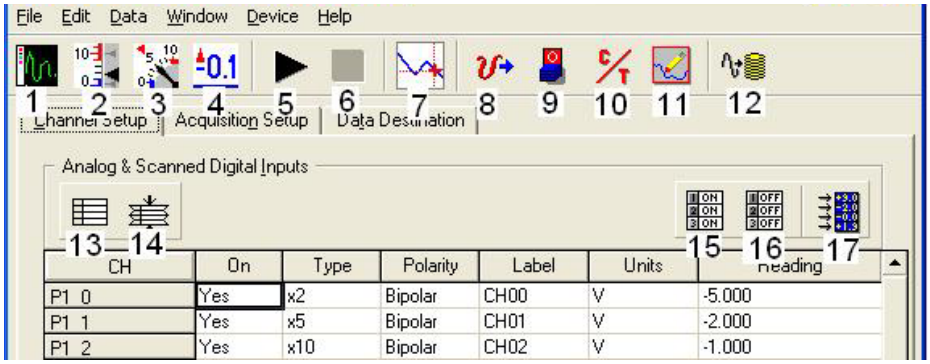


Acquisition Tab Selected

Note: The *Data Destination window* (not shown) lets you designate the directory for acquired data and the desired file formats.

(5) Collect Data

Click the Enable Readings Column button (17), or the Start All Indicators button (5); the data acquisition begins and the *readings* column becomes active. Click the Acquire button (12) to send the data to disk.



***DaqView Main Window*Channel Setup Tab Selected**

Main Window, a Brief Description of Button Control Functions		
#	**Item**	**Description**
1	Scope	Brings up a window from which Scope and/or Chart displays can be configured and used for analyzing data in relation to x and y axes.
2	Bar Graph Meters	Displays a bar graph meter.
3	Analog Meters	Displays an analog dial meter.
4	Digital Meters	Displays a digital meter.
5	Start All Indicators	Starts displaying data in the Reading column and any open Chart or Meters window.
6	Stop All Indicators	Stops displaying data in the Reading column and any open Chart or Meters window.
7	View File Data	Launches an independent post-data acquisition program, such as eZ-PostView, if installed. The data acquisition CD includes a PDF version of the post data acquisition document.
8	Analog Output	Displays the Analog Output window of the available DAC channels.
9	Digital I/O	Displays the Digital I/O window.
10	Counter/Timer	Displays the Counter/Timer window.
11	Waveform & Pattern Output	Displays the Arbitrary Waveform and Streamed Output windows.
12	Acquire	Activates an acquisition of data to a file.
13	Show ALL Channels	Expands Analog & Scanned Digital Inputs spreadsheet to show all channels, whether active or not.
14	Hide INACTIVE Channels	Condenses the Analog & Scanned Digital Inputs spreadsheet, to hide channels that are inactive.
15	Turn All Visible Channels ON	Turns all visible channels ON. Hidden channels will remain off.
16	Turn All Channels OFF	Turns all the channels OFF.
17	Channel Reading	A toggle button that enables [or disables] the Channel Reading column of the Analog and Scanned Digital Input spreadsheet. Some windows require the Channel Reading column to be disabled when changing channels or other parameters. This command is also available from the Data pull-down menu.

Click one of the toolbar's display icon buttons to see your data in the form of a scope or meter display. Button (1) brings up the scope window, which allows you to set up a scope and chart displays; buttons 2, 3, and 4 are for: bar graph meters, analog meters, and digital meters, respectively.

Customer Assistance

To report problems and receive support, call your service representative. Before calling for assistance, please refer to the portions of the *DaqBoard/3000USB User's Manual* that are relevant to your situation.

Reference Notes:

- Refer to the *DaqView* PDF for information regarding that application.
- Refer to the *DaqBoard/3000USB Series Users Manual* PDF for hardware related information, including pinouts and block diagrams.
- The default location for PDF documentation is in the Programs group, which can be accessed from the Windows Desktop.
- The PDFs can also be accessed directly from the Data Acquisition CD via the <View PDFs> button on the opening splash screen.
- The PDFs can also be accessed from our web site.

When you call, please have the following information available:

- Hardware model numbers
- Serial Numbers
- Software version numbers for DaqView
- Windows Operating System
- Type of computer and features

When returning equipment use original shipping containers or equivalent to prevent shipping damage. In addition to the above information, please be sure to include:

- The return authorization number (we provide you with this number after you contact us)
- The name and phone number of an individual who can discuss the problems encountered
- Any special instructions regarding return shipping
- A copy of troubleshooting notes and comments on tests performed and all problem-related conditions.

IOtech, Inc.
25971 Cannon Road
Cleveland, OH 44146-1833
Phone: (440) 439-4091
Fax: (440) 439-4093

e-mail (Product Information): sales@iotech.com
e-mail (Technical Support): productsupport@iotech.com
Internet: http://www.iotech.com

Device Overviews 1

Block Diagrams …… 1-1
Connections …… 1-3
Product Features …… 1-5
Software ……1-17

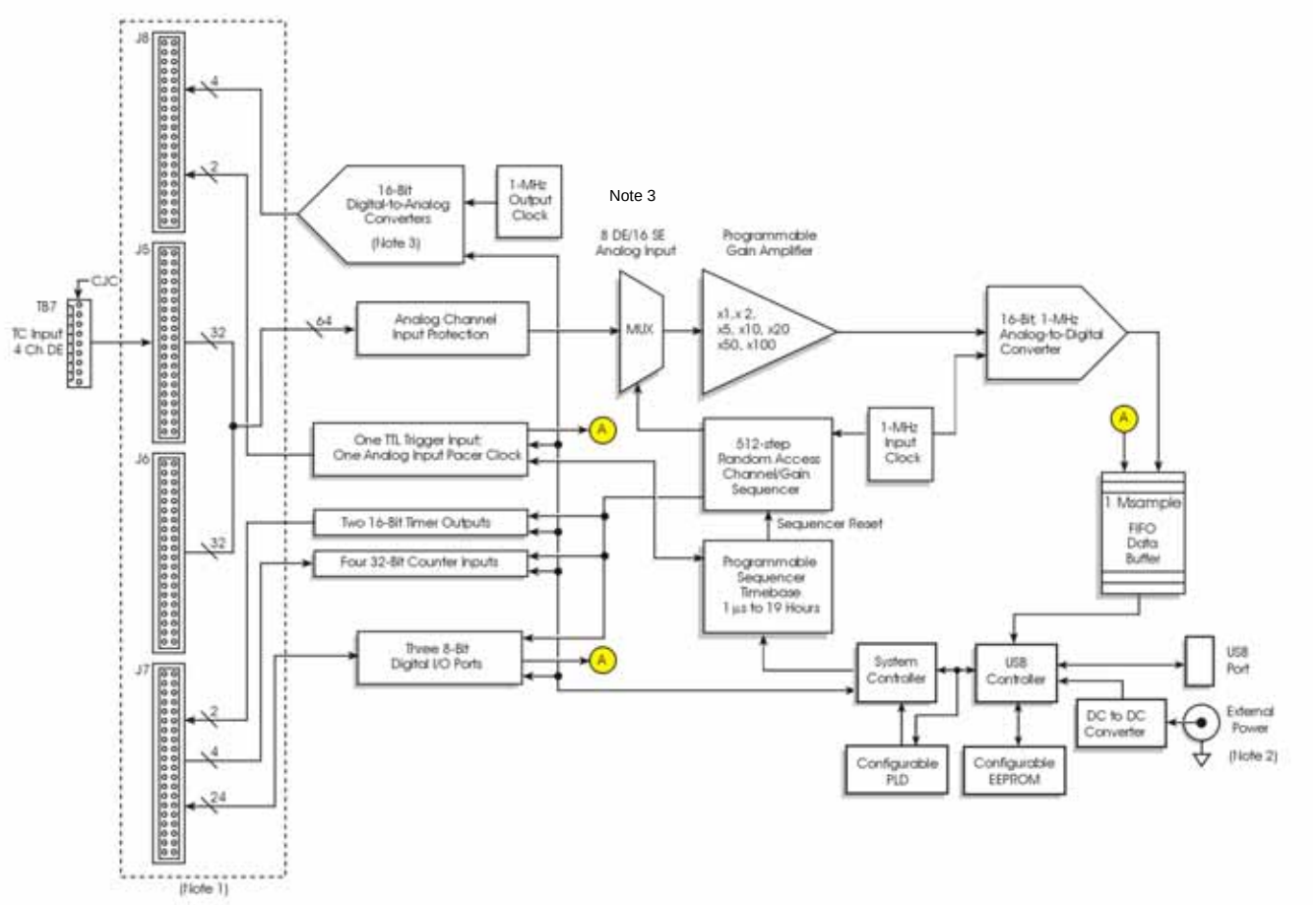
DaqView can only be used with one DaqBoard at a time. DASYLab and LabView can be used with multiple boards. For multiple board use (via custom programming) refer to the *Using Multiple Devices* section of the *Programmer's Manual*.

Reference Notes:

- The *Specifications* chapter (Chapter 7) includes a dimensional drawing of the DaqBoard/3000USB Series board.
- Chapter 2 includes pinouts and connection examples.
- Programming topics are covered in the *Programmer's User Manual* (p/n 1008-0901).
- As a part of product support, PDF versions of manuals are automatically loaded onto your hard drive during software installation. The default location is the Programs group, which can be accessed through the Windows Desktop.

DaqBoard/3000USB

Block Diagrams

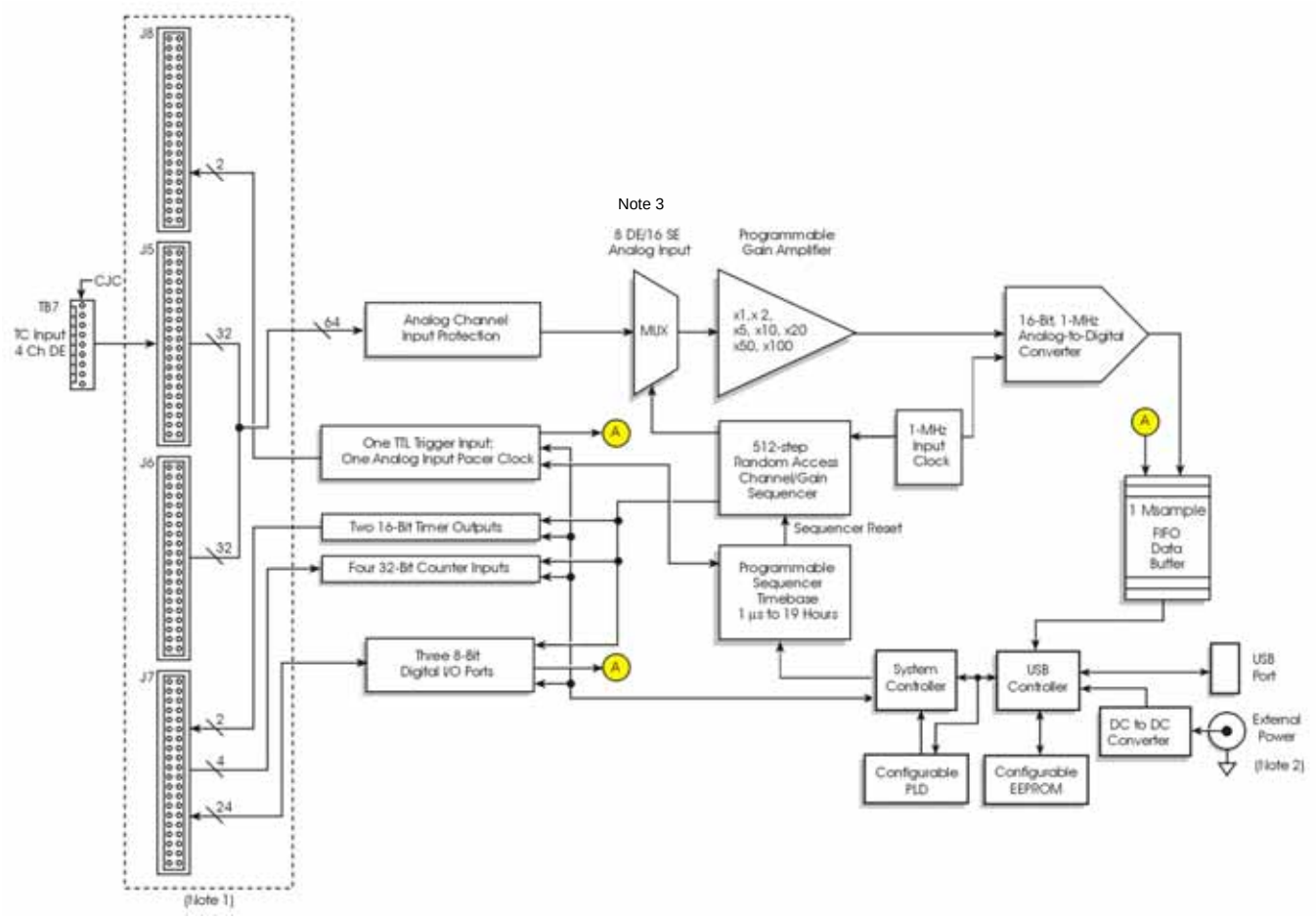


Block Diagram for DaqBoard/3001USB and /3031USB

Note 1: Pins for all digital I/O, counters, timers, and 16 analog inputs are on the 68-pin SCSI connector. Chapter 2 includes pinouts.

Note 2: Optional power source (TR-2 adapter) connects to the External Power connector if the USB cannot supply enough power. See *Specifications* (Chapter 7) in regard to power consumption.

Note 3: DaqBoard/3001USB can accept 16 Single-Ended, or 8 Differential analog inputs. DaqBoard/3031USB can accept 64 Single-Ended, or 32 Differential analog inputs. The /3001USB and /3031USB boards each have 4 analog outputs.



Block Diagram for DaqBoard/3005USB and /3035USB

Note 1: Pins for all digital I/O, counters, timers, and 16 analog inputs are on the 68-pin SCSI connector. Chapter 2 includes pinouts.

Note 2: Optional power source (TR-2 adapter) connects to the External Power connector if the USB cannot supply enough power. See *Specifications* (Chapter 7) in regard to power consumption.

Note 3: DaqBoard/3005USB can accept 16 Single-Ended, or 8 Differential analog inputs. DaqBoard/3035USB can accept 64 Single-Ended, or 32 Differential analog inputs. The /3005USB and /3035USB boards have no analog outputs.

Connections

SCSI - 68 pin (P5)

The 68-pin SCSI connector includes pins for the following. Chapter 2 includes a pinout.

- 16SE / 8DE analog inputs (Ch 0 thru 15)
- 24 digital I/O
- 4 counter inputs
- 2 timer outputs
- A/D pacer clock I/O
- DAC pacer clock I/O
- TTL trigger
- +5 VDC
- self calibration
- analog commons
- digital commons
- up to four DACs (according to board model)

You can connect a TB-100 screw-terminal board or a DBK215 BNC screw-terminal module to the SCSI connector via one of the following cables.

CA-G55	68-conductor ribbon expansion cable. 3 feet.
CA-G56	68-conductor shielded expansion cable. 3 feet.
CA-G56-6	68-conductor shielded expansion cable. 6 feet.

40-pin Headers (J5, J6, J7, J8)

Four 40-pin headers (J5 through J8) provide an alternative connection to the signals of the SCSI connector. Also, for the /3031USB and /3035USB, the J5 and J6 headers accept additional analog input for a total of 64 Single Ended, or 32 Differential. You can obtain a male DB37 connector for each header by connecting a CA-248 (40-pin to male DB-37 cable) to each header.

9-slot Screw Terminal (TB7)

The on-board screw terminal connector (TB7) can be used to connect up to four thermocouple inputs. TB7 uses the following analog channels [which can also be accessed via the SCSI connector and J5] to obtain its 4 differential channels:

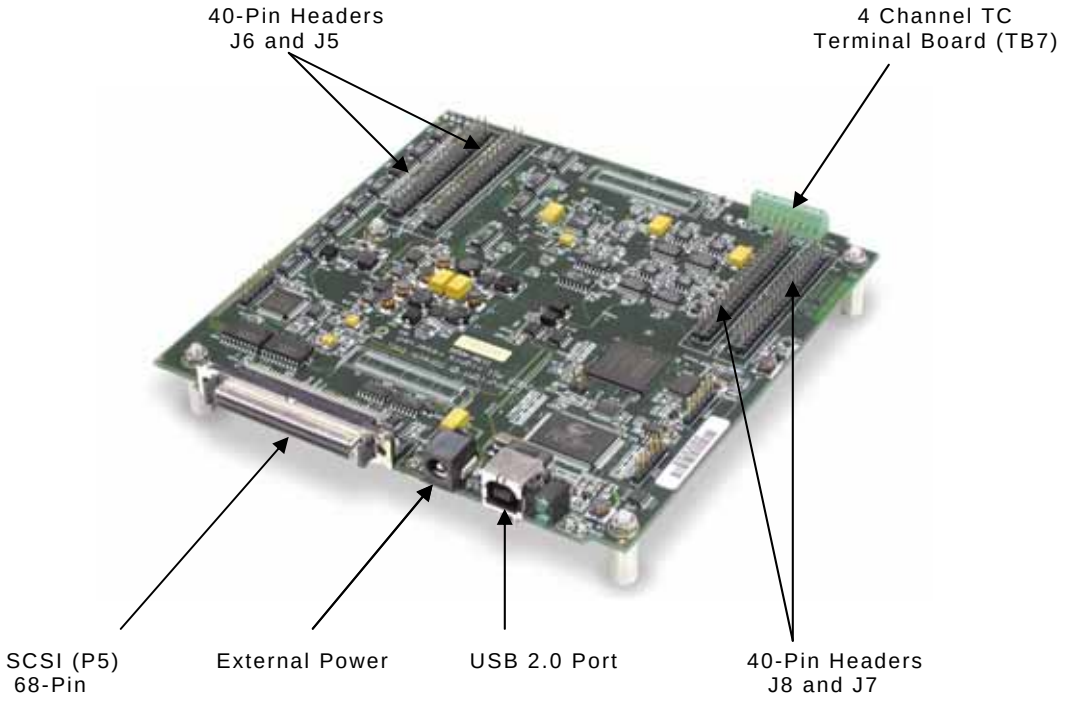
TC CH0: CH 0 (+); CH 8 (-) TC CH1: CH 1 (+); CH 9 (-) TC CH2: CH 2 (+); CH 10 (-)

TC CH3: CH 3 (+); CH 11 (-)

As stated in the WARNINGS of the pinout and connection chapter (Chapter 2), care must be taken to avoid redundant connections!

External Power

Although the 3000USB Series boards are powered via a USB port on a host PC, an external power connector is available for cases in which the host PC's USB port cannot supply adequate power, or for when the user prefers a separate power source. The TR-2 is an optional power supply available for this purpose. The TR-2 plugs into a standard 120VAC outlet and will supply 9VDC, 1 amp power to the board via its external power connector (see figure).



Location of Connectors

Product Features

I/O Comparison Matrix

Model	Analog Input Channels	Analog Output Channels	Digital I/O Channels	Counter Inputs	Timer Outputs
DaqBoard/3001USB	16SE / 8DE	4	24	4	2
DaqBoard/3005USB	16SE / 8DE	0	24	4	2
DaqBoard/3031USB	64SE / 32DE	4	24	4	2
DaqBoard/3035USB	64SE / 32DE	0	24	4	2

The DaqBoard/3000USB Series boards feature a 16-bit/1-MHz A/D converter, 16 analog input channels [user expandable up to 64 for the /3031USB and 3035USB models], up to four 16-bit/1-MHz analog outputs [for models /3001USB and /3031USB], 24 high-speed digital I/O channels, 2 timer outputs, and four 32-bit counters.

All analog I/O, digital I/O, and counter/timer I/O can operate synchronously and simultaneously, guaranteeing deterministic I/O timing amongst all signal types. The DaqBoard/3000USB Series boards include a high-speed, low-latency, highly deterministic control output mode that operates independent of the PC. In this mode both digital and analog outputs can respond to analog, digital and counter inputs as fast as 2µsec.

Other Hardware Features Include:

- Encoder measurements up to 20 MHz, including Z-channel zeroing
- Frequency and Pulse-width measurements with 20.83 nsec resolution
- A Timing mode that can measure the time between two counter inputs to 20.83 nsec resolution
- Self-calibration

The DaqBoard/3000USB series offers up to 4-MHz scanning of all digital input lines. Digital inputs and counter inputs can be synchronously scanned [along with analog inputs] but do not affect the overall A/D rate because they use no time slot in the scanning sequencer. For example, one analog input can be scanned at the full 1-MHz A/D rate along with digital and counter input channels. The 1-MHz A/D rate is unaffected by additional digital and counter channels.

An additional 48 single-ended [or 24 differential] analog input channels are included with models /3031USB and /3035USB through their J5 and J6 headers (two of the four the onboard 40-pin headers, *see pinout chapter 2*). Typically, a CA-248 cable is connected to the header to provide a DB37 connection option. The CA-248 cables have a 40-pin header at one end and a male DB-37 connector at the other. A pinout for the CA-248 is provided in Chapter 2.

With the boards' 1-MHz aggregate sample rate, users can easily add multiple analog expansion channels to the /3031USB and /3035USB boards and still have enough bandwidth to have a per-channel sample rate in the multiple kHz range.

Signal I/O

One 68-pin connector provides access to the 16SE/8DE analog input channels, 24 digital I/O lines, counter/timer channels, and analog outputs (when applicable). Redundant connectivity is found in four 40-pin headers; two of which provide each DaqBoard/3031USB and /3035USB board with expansion capability for having a total of 64 single-ended [or 32 differential] channels.

Reference Note:
In regard to analog expansion, refer to the J5 and J6 pinouts in chapter 2.

Analog Input

Each DaqBoard/3000USB Series board has a 16-bit, 1-MHz A/D coupled with 16 single-ended, or 8 differential analog inputs [up to 64 SE or 32 DE for /3031USB and /3035USB boards]. Seven software programmable ranges provide inputs from ±10V to ±100 mV full scale. Each channel can be software-configured for a different range, as well as for single-ended or differential bipolar input. Each differential channel can accept any type of thermocouple input.

Synchronous I/O

The DaqBoard/3000USB series has the ability to make analog measurements and scan digital and counter inputs. In addition, DaqBoard/3001USB and /3031USB boards can synchronously generate up to four analog outputs.

Additionally, while digital inputs and counter inputs can be synchronously scanned along with analog inputs, they do not affect the overall A/D rate because they use no time slot in the scanning sequencer. For example, one analog input can be scanned at the full 1-MHz A/D rate along with digital and counter input channels. The 1-MHz A/D rate is unaffected by the additional digital and counter channels.

Input Scanning

DaqBoard/3000USB Series devices have several scanning modes to address a wide variety of applications. A 512-location scan buffer can be loaded by the user with any combination of analog input channels. All analog input channels in the scan buffer are measured sequentially at 1 µsec per channel. The user can also specify that the sequence repeat immediately, or repeat after a programmable delay from 0 to 19 hours, with 20.83 nsec resolution. For example, in the fastest mode, with a 0 delay, a single analog channel can be scanned continuously at 1 Msamples/s; two analog channels can be scanned at 500K samples/s each; 16 analog input channels can be scanned at 62.5 Ksamples/s.

The digital and counter inputs can be read in several modes. First, via software the digital inputs or counter inputs can be read *asynchronously* at anytime before, during, or after an analog input scan sequence. This software mode is not deterministic as to exactly when a digital or counter input is read relative to an analog input channel.

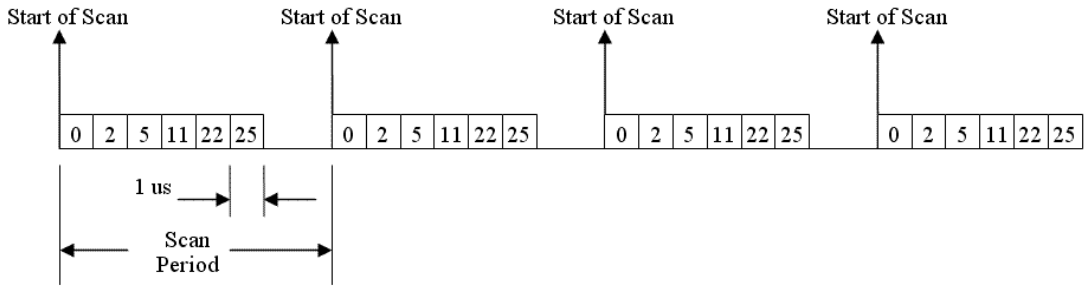
In either of the two synchronous modes, the digital inputs and/or counter inputs are read with deterministic time correlation to the analog inputs. In the *once-per-scan mode*, all of the enabled digital inputs and counter inputs are read during the first analog measurement of an analog input scan sequence. The advantage of this mode is that the digital and counter inputs do not consume an analog input time slot, and therefore do not reduce the available bandwidth for making analog input measurements. For example, presume all 24 bits of digital input are enabled, and all four 32-bit counters are enabled, and eight channels of analog inputs are in the scan sequence at full 1µsec/channel rate. At the beginning of each analog input scan sequence, which would be 8 µsec in total duration, all digital inputs and counter inputs will be measured and sent to the PC during the first µsec of the analog scan sequence.

Another synchronous mode allows digital inputs to be scanned every time an analog input channel is scanned. For example, if eight analog inputs are scanned at 1 µsec per channel continuously, and 24 bits of digital inputs are enabled, then the 24 bits of digital inputs will be scanned at 24 bits per 1 µsec. If counters are enabled in this mode, they will be scanned at once per scan, in the same manner as in the first example above.

Note: It is not necessary to read counters as often as it is to read digital inputs. This is because counters continue to count pulses regardless of whether or not they are being read by the PC.

Example 1: Analog channel scanning of voltage inputs

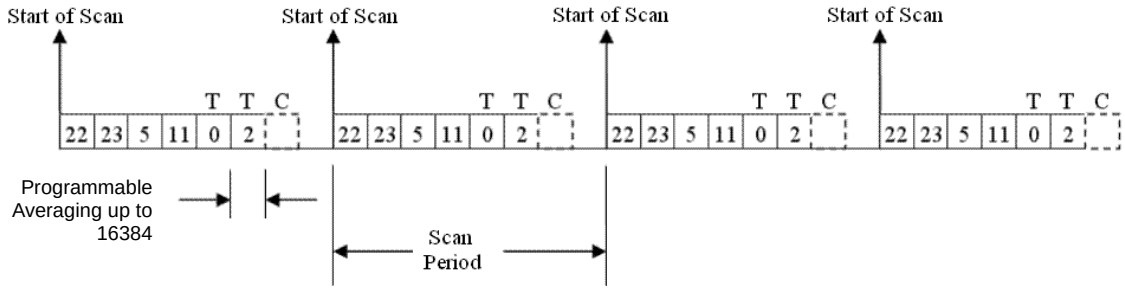
The figure below shows a simple acquisition. The scan is programmed pre-acquisition and is made up of 6 analog channels (Ch0, Ch2, Ch5, Ch11, Ch22, Ch25.) Each of these analog channels can have a different gain. The acquisition is triggered and the samples stream to the PC via USB2. Each analog channel requires one microsecond of scan time therefore the scan period can be no shorter than 6 us for this example. The scan period can be made much longer than 6 us, up to 19 hours. The maximum scan frequency is one divided by 6us or 166,666 Hz.



All analog channels are sampled at the same rate of 1us.

Example 2: Analog channel scanning of voltage and temperature inputs

The scan is programmed pre-acquisition and is made up of 6 analog channels (Ch0, Ch2, Ch5, Ch11, Ch22, Ch23.) Each of these analog channels can have a different gain. Channels 0 and 2 can be programmed to directly measure thermocouples. In this mode, oversampling is programmable up to 16384 oversamples per channel in the scan group. When oversampling is applied, it is applied to all analog channels in the scan group, including temperature and voltage channels. (Digital channels are not oversampled.) If the desired number of oversamples is 256 then each analog channel in the scan group will take 256 microseconds, the returned 16-bit value represents an average of 256 consecutive 1us samples of that channel. The acquisition is triggered and 16-bit values (each representing an average of 256) stream to the PC via USB2. Since two of the channels in the scan group are temperature channels, the acquisition engine will be required to read a cold-junction-compensation (CJC) temperature every scan.



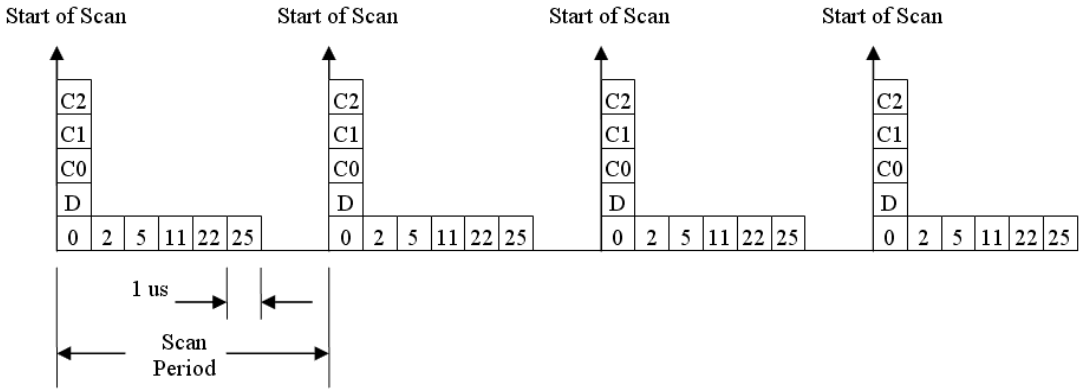
In this example, the desired number of oversamples is 256, therefore each analog channel in the scan group requires 256 microseconds to return one 16-bit value. The oversampling is also done for CJC temperature measurement channels. The minimum scan period for this example is therefore 7 X 256 us or 1792 microseconds. The maximum scan frequency is the inverse of this number, 558 Hz.

Autozero may also be employed. This adds more channels to the scan group and further reduces the maximum scan frequency. Autozero channels read an on-board, shorted analog input. Auto-zeroing reduces drift due to fluctuating ambient temperatures or ambient temperatures outside the DC specifications.

Reference Note:
Appendix B includes detailed information regarding signal modes, methods of noise reduction, and averaging techniques.

Example 3: Analog and digital channel scanning, once per scan mode

The scan is programmed pre-acquisition and is made up of 6 analog channels (Ch0, Ch2, Ch5, Ch11, Ch22, Ch25) and 4 digital channels (16-bits of digital IO, 3 counter inputs.) Each of the analog channels can have a different gain and each of the counter channels can be put into a different mode (totalizing, pulsewidth, encoder, etc.) The acquisition is triggered and the samples stream to the PC via USB2. Each analog channel requires one microsecond of scan time therefore the scan period can be no shorter than 6 us for this example. All of the digital channels are sampled at the start of scan and do not require additional scanning bandwidth as long as there is at least one analog channel in the scan group. The scan period can be made much longer than 6 us, up to 19 hours. The maximum scan frequency is one divided by 6us or 166,666 Hz.

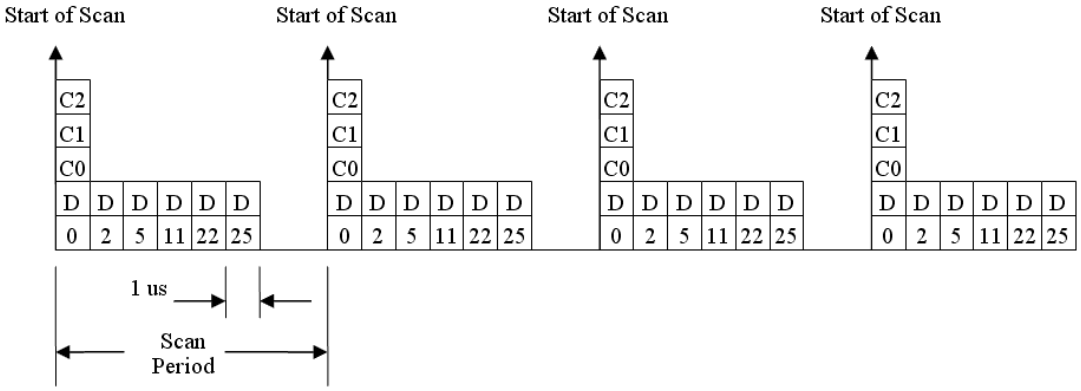


The counter channels could be returning only the lower 16-bits of count value if that is sufficient for the application. They could also be returning the full 32-bit result if necessary. Similarly, the digital input channel could be the full 24 bits if desired or only 8 bits if that is sufficient. If the 3 counter channels are all returning 32 bit values and the digital input channel is returning a 16 bit value, then 13 samples are being returned to the PC every scan period, each sample being 16-bits. 32-bit counter channels are divided into two 16-bit samples, one for the low word and the other for the high word. If the maximum scan frequency is 166,666 Hz then the data bandwidth streaming into the PC is 2.167 MSamples per second. Some slower PCs may have a problem with data bandwidths greater than 6 MSamples per second.

All DaqBoard/3000USB Series devices have an onboard 1MSample buffer for acquired data.

Example 4: Sampling digital inputs for every analog sample in a scan group

The scan is programmed pre-acquisition and is made up of 6 analog channels (Ch0, Ch2, Ch5, Ch11, Ch22, Ch25) and 4 digital channels (16-bits of digital input, 3 counter inputs.) Each of the analog channels can have a different gain and each of the counter channels can be put into a different mode (totalizing, pulsewidth, encoder, etc.) The acquisition is triggered and the samples stream to the PC via USB2. Each analog channel requires one microsecond of scan time therefore the scan period can be no shorter than 6 us for this example. All of the digital channels are sampled at the start of scan and do not require additional scanning bandwidth as long as there is at least one analog channel in the scan group. The 16-bits of digital input are sampled for every analog sample in the scan group. This allows up to 1MHz digital input sampling while the 1MHz analog sampling bandwidth is aggregated across many analog input channels. The scan period can be made much longer than 6 us, up to 19 hours. The maximum scan frequency is one divided by 6us or 166,666 Hz. Note that digital input channel sampling is not done during the "dead time" of the scan period where no analog sampling is being done either.



If the 3 counter channels are all returning 32 bit values and the digital input channel is returning a 16 bit value, then 18 samples are being returned to the PC every scan period, each sample being 16-bits. 32-bit counter channels are divided into two 16-bit samples, one for the low word and the other for the high word. If the maximum scan frequency is 166,666 Hz then the data bandwidth streaming into the PC is 3 MSamples per second. Some slower PCs may have a problem with data bandwidths greater than 6 MSamples per second.

All DaqBoard/3000USB Series devices have an onboard 1MSample buffer for acquired data.

Analog Input & Channel Expansion

Each DaqBoard/3000USB Series board has a 16-bit, 1-MHz A/D coupled with 16 single-ended, or 8 differential analog inputs. Seven software programmable ranges provide inputs from ±10V to ±100 mV full scale. Each channel can be software-configured for a different range, as well as for single-ended or differential bipolar input.

Adding additional analog input channels to the /3031USB and /3035USB boards is easy using J5 and J6 (two of the four on-board 40-pin headers). You can obtain male DB37 connectors for the headers by using a CA-248 cable (1 per header).

Measurement speed of the expansion channels is the same 1 Msample/s exhibited by the primary channels.

Reference Notes:
Pinouts for all DaqBoard/3000USB on-board connectors are provided in chapter 2.

USB2.0 versus USB1.1

Connecting a DaqBoard/3000USB Series board to a USB1.1 port or hub will result in lower transfer speed which may not support continuous data collection at high scan rates. Note that *Hi-Speed* (USB2.0) ports are at least forty times faster than the earlier *Full-Speed* (USB1.1) versions.

When the host computer has a board with USB 2.0 ports, an "Enhanced" USB controller can be found in the Device Manager. The Device Manager will also show two other USB controllers. This is due to the fact that USB2.0 circuitry includes 3 chips [one for the actual USB2.0 capable devices and two for backward USB1.1 compatibility]. Thus a USB 2.0 motherboard can host any USB device (version 2.0 or lower), assuming there are no defects with the board, system, and/or device.

Notes on USB Hubs:

- USB 1.1 (obsolete) hubs will work on USB 2.0 ports, but cannot utilize USB 2.0 capabilities.
- Hi-Speed and Full/Low-Speed USB devices can coexist on USB 2.0 hubs.
- USB 2.0 hubs can be used on computers with USB 1.1 ports, but will not exhibit USB 2.0 capabilities.
- Minimize hub use and keep USB cables as short as possible.
- Regardless of the USB hub or port used, if power to the DaqBoard/3000USB Series board is insufficient, connect a TR-2 power adapter to the unit's External Power jack.
- Only self-powered hubs can supply sufficient power (500 mA at 5V nominal). Verify that the AC-to-DC power supply for the self-powered hub can supply at least 2.1 amps at 5 volts.
- In general, do not use more than three DaqBoard/3000USB systems per one self-powered hub.

Triggering

Triggering can be the most critical aspect of a data acquisition application. The DaqBoard/3000USB Series supports a full complement of trigger modes to accommodate any measurement situation.

Hardware Analog Triggering. TheDaqBoard/3000USB Series uses true analog triggering, whereby the trigger level programmed by the user sets an analog DAC, which is then compared in hardware to the analog input level on the selected channel. The result is analog trigger latency which is guaranteed to be less than1.3 µs. Any analog channel can be selected as the trigger channel. The user can program the trigger level, as well as the rising or falling edge and hysteresis.

When the starting out analog input voltage is near the trigger level, and you are performing a rising [or falling] hardware analog level trigger, it is possible that the analog level comparator will have already tripped, i.e., to have tripped before the sweep was enabled.
If this is the case, the circuit will wait for the comparator to change state. However, since the comparator has already changed state, the circuit will not see the transition.

Solution:

(1) Set the analog level trigger to the desired threshold.

(2) Apply an analog input signal that is *more than* 2.5% of the full-scale range *away from the desired threshold*. This ensures that the comparator is in the proper state at the beginning of the acquisition.

(3) Bring the analog input signal toward the desired threshold. When the input signal is at the threshold (± some tolerance) the sweep will be triggered.

(4) Before re-arming the trigger, again move the analog input signal to a level that is more than 2.5% of the full-scale range *away from* the desired threshold.

Example:

- an engineer is using the ±2V full-scale range (gain = 5)
- he desires to trigger at +1V on the rising edge
- he sets the analog input voltage to an initial start-value which is *less than* +0.9V (1V – (2V * 2 * 2.5%)).

Digital Triggering. A separate digital trigger input line is provided, allowing TTL-level triggering with latencies guaranteed to be less than 1 µs. Both the logic levels (1 or 0), as well as the rising or falling edge can be programmed for the discrete digital trigger input.

Pattern Triggering. The user can specify a 16-bit digital pattern to trigger an acquisition, including the ability to mask or ignore specific bits.

Software-Based Channel Level Triggering. This mode differs from the modes just discussed because the readings [analog, digital, or counter] are interrogated by the PC in order to detect the trigger event. Triggering can also be programmed to occur when one of the counters reaches, exceeds, or is within a programmed window.

Any of the built-in counter/totalizer channels can be programmed as a trigger source. Triggers can be detected on scanned digital input channel patterns as well. Normally software-based triggering results in long latencies from the moment a trigger condition is detected until the instant data is acquired. However, theDaqBoard/3000USB Series circumvents this undesirable situation by use of pre-trigger data. Specifically, when software-based-triggering is employed, and the PC detects that a trigger condition has occurred, (which may be thousands of readings after the actual occurrence of the signal), the DaqBoard driver automatically looks back to the location in memory, to where the actual trigger-causing measurement occurred. The acquired data presented to the user begins at the point where the trigger-causing measurement occurs. The maximum latency in this mode is equal to one scan period.

Multi-Channel Triggering. The DaqBoard/3000USB Series board can be configured to trigger on any combination of analog, digital, and/or counter input; however, not on temperature measurements. In the multi-channel triggering mode, the maximum latency is one scan period.

Triggering can occur based on a logical “and” or a logical “or” of the multiple trigger conditions. For example, a trigger condition could be programmed to occur for when the following three conditions are met:

a) three analog input channels each reach their respective trigger level
b) AND two digital inputs are in the specified logic state
c) AND three counters exceed a specified frequency

Stop Trigger. Any of the software trigger modes previously described, including scan count, can be used to stop an acquisition. Thus an acquisition can be programmed to begin on one event, such as a voltage level, and then can stop on another event, such as a digital pattern.

Pre-Triggering and Post-Triggering Modes. Six modes of pre-triggering and post-triggering are supported, providing a wide variety of options to accommodate any measurement requirement. When using pre-trigger, the user must use software-based triggering to initiate an acquisition. The six modes are:

- ***No pre-trigger, post-trigger stop event***. This, the simplest of modes, acquires data upon receipt of the trigger, and stops acquiring upon receipt of the stop-trigger event.
- ***Fixed pre-trigger with post-trigger stop event***. In this mode, the user specifies the number of pre-trigger readings to be acquired, after which, acquisition continues until a stop-trigger event occurs.
- ***No pre-trigger, infinite post-trigger***. No pre-trigger data is acquired in this mode. Instead, data is acquired beginning with the trigger event, and is terminated when the operator issues a command to halt the acquisition.
- ***Fixed pre-trigger with infinite post-trigger***. The user specifies the amount of pre-trigger data to acquire, after which the system continues to acquire data until the program issues a command to halt acquisition.
- ***Variable pre-trigger with post trigger stop event***. Unlike the previous pre-trigger modes, this mode does not have to satisfy the pre-trigger number of readings before recognizing the trigger event. Thus the number of pre-trigger readings acquired is variable and dependent on the time of the trigger event relative to the start. In this mode, data continues to be acquired until the stop trigger event is detected. *Driver support only*.

- ***Variable pre-trigger with infinite post trigger***. This is similar to the mode described above, except that the acquisition is terminated upon receipt of a command from the program to halt the acquisition. *Driver support only*.

Calibration

Every range of a DaqBoard/3000USB Series device is calibrated at the factory using a digital NIST traceable calibration method. This method works by storing a correction factor for each range on the unit at the time of calibration. The user can adjust the calibration of the board while it is installed in the acquisition system without destroying the factory calibration. This is accomplished by having 3 distinct calibration tables in the on-board EPROM.

The user can select any of the three cal tables provided [factory, user, or self-cal tables] by API call or from within software. Self-cal can be performed automatically via the included software and without the use of external hardware or instruments. Self-cal derives its tracebility through an on-board reference which has a stability of 0.005% per year.

Note that a 2-year calibration period is recommended for DaqBoard/3000USB Series boards.

Reference Note:
Chapter 4, *Calibration*, discusses using a temperature calibrator with a DaqBoard/3000USB Series board.

Analog Output

DaqBoard/3001USB and /3031 Only

DaqBoard/3001USB and /3031USB each have four 16-bit, 1 MHz analog output channels. The channels have an output range of -10V to +10V. This can be read from PC RAM or from a file on the hard disk. In addition, a program can asynchronously output a value to any of the D/As for non-waveform applications, presuming that the D/A is not already being used in the waveform output mode.

A program can asynchronously output a value to any of the D/As for non-waveform applications, presuming that the D/A is not already being used in the waveform output mode.

Each of the analog outputs can be used in a control mode, where their output level is dependent on whether an associated analog, digital or counter input is above or below a user-specified limit condition.

When used to generate waveforms, the D/As can be clocked in several different modes. Each D/A can be separately selected to be clocked from one of the following sources.

- **Asynchronous Internal Clock**. The on-board programmable clock can generate updates ranging from 19 hours to 1 MHz, independent of any acquisition rate.
- **Synchronous Internal Clock**. The rate of analog output update can be synchronized to the acquisition rate derived from 1 MHz to once every 19 hours.
- **Asynchronous External Clock**. A user-supplied external input clock can be used to pace the D/A, entirely independent of analog inputs.
- **Synchronous External Clock**. A user-supplied external input clock can pace both the D/A and the analog input.

Digital Inputs and Outputs

Twenty-four TTL-level digital I/O lines are included in each of the DaqBoard/3000USB Series boards. Digital I/O can be programmed in 8-bit groups as either inputs or outputs and can be scanned in several modes (see *Input Scanning*). Ports programmed as input can be part of the scan group and *scanned along with analog input channels*, or can be asynchronously accessed via the PC at any time, including when a scanned acquisition is occurring.

Two synchronous modes are supported when digital inputs are scanned along with analog inputs.

- **Scanning digital inputs at the start of each scan sequence**. In this mode the digital inputs are scanned at the start of each scan sequence, which means the rate at which they are scanned is dependent on the number of analog input channels and the delay period. For example, if 8 analog inputs were enabled with a 0 delay period, then the digital inputs in this mode would be scanned at once per 8µsec, i.e., 125 kHz.
- **Scanning digital inputs synchronously with every analog input channel**. In this synchronous mode, the enabled digital inputs are scanned synchronously with every analog input channel. So in the preceding example the digital inputs would be scanned at once per µsec, or 1 MHz. If no analog inputs were being scanned the digital inputs could be scanned at up to 4 MHz.

Digital Outputs and Pattern Generation

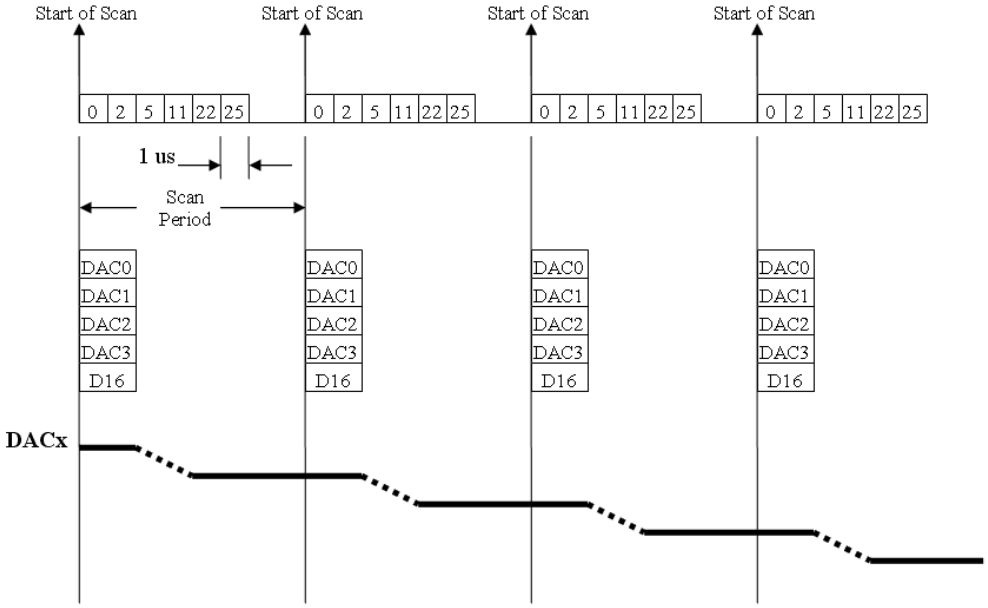
Digital outputs can be updated asynchronously at anytime before, during or after an acquisition. Two of the 8-bit ports can also be used to generate a 16-bit digital pattern at up to 4 MHz. In the same manner as analog output, the digital pattern can be read from PC RAM or a file on the hard disk. Digital pattern generation is clocked in the same four modes as described with analog output.

The ultra low-latency digital output mode allows a digital output to be updated based on the level of an analog, digital or counter input. In this mode, the user associates a digital output bit with a specific input, and specifies the level of the input where the digital output changes state. The response time in this mode is dependent on the number of input channels being scanned, and can typically be in the range of 2 to 20 µsec.

Reference Note:
For detailed information regarding low latency control outputs, see Chapter 6.

Example 5: Analog channel scanning of voltage inputs and streaming analog outputs

The figure below shows a simple acquisition. The scan is programmed pre-acquisition and is made up of 6 analog channels (Ch0, Ch2, Ch5, Ch11, Ch22, Ch25.) Each of these analog channels can have a different gain. The acquisition is triggered and the samples stream to the PC via USB2. Each analog channel requires one microsecond of scan time therefore the scan period can be no shorter than 6 us for this example. The scan period can be made much longer than 6 us, up to 19 hours. The maximum scan frequency is one divided by 6us or 166,666 Hz.



This example has all 4 DACs being updated and the 16-bits of digital IO. These updates are performed at the same time as the acquisition pacer clock (also called the scan clock.) All 4 DACs and the 16-bits of pattern digital output are updated at the beginning of each scan. Note that the DACs will actually take up to 4 us after the start of scan to settle on the updated value. This is due to the amount of time to shift the digital data out to the DACs plus the actual settling time of the digital to analog conversion.

The data for the DACs and pattern digital output comes from a PC-based buffer. The data is streamed across the USB2 bus to the board.

It is possible to update the DACs and pattern digital output with the DAC pacer clock (either internally generated or externally applied.) In this case, the acquisition input scans are not synchronized to the analog outputs or pattern digital outputs. It is possible to synchronize everything (input scans, DACs, pattern digital outputs) to one clock. That clock can be either internally generated or externally applied.

Counter Inputs

Four 32-bit counters are built into each DaqBoard/3000USB Series board. Each of the four counters accepts frequency inputs up to 20 MHz. The high-speed counter channels can be configured on a per-channel basis. Possible configurations include the following modes:

- **Counter**
- **Period**
- **Pulse width**
- **Time between edges**
- **Multi-axis quadrature encoder**

Reference Note:
For detailed information regarding the various counter modes refer to Chapter 5, *Counter Input Configuration Modes*.

The counters can concurrently monitor time periods, frequencies, pulses, and other event driven incremental occurrences directly from encoders, pulse-generators, limit switches, proximity switches, and magnetic pick-ups.

As with all other inputs to the boards, the counter inputs can be read asynchronously under program control, or synchronously as part of an analog and digital scan group based on a programmable internal timer or an external clock source.

The boards support quadrature encoders with up to 2 billion pulses per revolution, 20 MHz input frequencies, and x1, x2, x4 count modes. With only A-phase and B-phase signals, 2 channels are supported. With A-phase, B-phase, and Z-index signals, 1 channel is supported.

Each input can be debounced from 500 ns to 25.5 ms (total of 16 selections) to eliminate extraneous noise or switch induced transients. Encoder input signals must be within -5V to +10V and the switching threshold is TTL (1.3V).

Timer Outputs

Two 16-bit timer outputs are built into every 3000 series board. Each timer is capable of generating a different square wave with a programmable frequency in the range of 16 Hz to 1 MHz.

Example 6: Timer Outputs

Timer outputs are programmable square waves. The period of the square wave can be as short as 1us or as along as 65536 us. See the table below for some examples.

Divisor*	Timer Output Frequency	Related Equations
0	1 MHz	F = 1 MHz / (Divisor + 1) Divisor = (1 MHz / F) - 1
99	10 kHz	
999	1 kHz	
4999	200 Hz	
9999	100 Hz	
65535	*Turns Timer OFF* *	

* The divisor range is 0 to 65535. For Setpoint Operation 65535 turns the timer off. In Asynchronous Write, 65535 results in a timer output frequency of 15.259 Hz.

There are 2 timer outputs that can generate different square waves. The timer outputs can be updated asynchronously at any time. Both timer outputs can also be updated during an acquisition as the result of setpoints applied to analog or digital inputs. See the section on pattern detection setpoints for more information and examples.

Multiple DaqBoard/3000USB Boards

When multiple boards are used they can be operated synchronously. This is done by designating one board as the master. The other boards [slaves] are synchronized to the master by the pacer clock which is externally routed to the designated slave boards.

For two or more boards to be operated synchronously:

(1) Use coax (or twisted-pair wire) to either (a) connect the APCR signals together, *or* (b) connect the DPCR signals together.

(2) Connect Digital Common [of each board] to one of the twisted pairs, *or* to the shield of the coax.

Software

Included with the /3000 Series is a complete set of drivers and example programs for the most popular programming languages and software packages. Driver support includes Visual Basic®, C/C++, LabVIEW®, DASYLab®, and MATLAB®. DaqCOM™ provides Windows®-basedActiveX/COM-based programming tools for Microsoft® VisualStudio® and VisualStudio.NET®. Also included with the /3000 Series is new DaqView™ software, a comprehensive Out-of-the-Box™ application that enables set-up, data logging, and real-time data viewing without existing programming skills. Optional DaqView/Pro also adds features such as direct-to-Excel® enhancements, FFT analysis, statistics, etc. DaqView software provides Out-of-the-Box™, quick and easy set up and collection of data.

Daq devices have software options capable of handling most applications. Three types of software are available:

- Ready-to-use graphical programs, e.g., DaqView, DaqViewXL, and post acquisition data analysis programs such as PostView, DIAdem, and eZ-PostView
- Drivers for third-party, icon-driven software such as DASYLab and LabView
- Various language drivers to aid custom programming using API

Ready-to-use programs are convenient for fill-in-the-blank applications that do not require programming for basic data acquisition and display:

- DaqView is a Windows-based program for basic set-up and data acquisition. DaqView lets you select desired channels, gains, transducer types (including thermocouples), and a host of other parameters with a click of a PC's mouse. DaqView lets you stream data to disk and display data in numerical or graphical formats. PostView is a post-acquisition waveform-display program within DaqView.
- ViewXL/Plus allows you to interface directly with Microsoft Excel to enhance data handling and display. Within Excel you have a full-featured Daq control panel and all the data display capabilities of Excel.
- Post acquisition data analysis programs, e.g., PostView, DIAdem, and eZ-PostView, typically allow you to view and edit post-acquisition data.
- The Daq Configuration control panel allows for interface configuration, testing, and troubleshooting.

Each Daq system comes with an Application Programming Interface (API). API-language drivers include C/C++ and Visual Basic. The latest software is a 32-bit version API.

Reference Notes:

- The software documents for: *DaqView*, *ViewXL*, and *Post Acquisition Data Analysis* are not included as part of the hardcopy manual, but are available in PDF version. See the PDF Note, below.
- Programming topics are covered in the *Programmer's User Manual* (1008-0901). As a part of product support, this manual is automatically loaded onto your hard drive during software installation. The default location is the Programs directory, which can be accessed through the Windows Desktop.

PDF Note: During software installation, Adobe® PDF versions of user manuals will automatically install onto your hard drive as a part of product support. The default location is in the **Programs** directory, which can be accessed from the *Windows Desktop*. Refer to the PDF documentation for details regarding both hardware and software.

A copy of the Adobe Acrobat Reader® is included on your CD. The Reader provides a means of reading and printing the PDF documents. Note that hardcopy versions of the manuals can be ordered from the factory.

Connections and Pinouts 2

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J5 and J6, 40-Pin Headers for Analog Channels***…… 2-3***

TB7 4-Channel Thermocouple Terminal Block ***…… 2-3***

J7 and J8, 40-Pin Headers for Digital Ports, Counters, Timers, DACS, Triggers, Pacer Clocks and Other Signals ***…… 2-4***

CA-248, 40-Position Header to DB-37 Male, Ribbon Cable …… **2-5**

TB-100 Terminal Connector Option ***…… 2-6***

TB-101 Terminal Board Option ***…… 2-7***

DBK215 16-Connector BNC Connection Module Option ***…… 2-11***

Hardware Setups …… 2-12

WARNING !

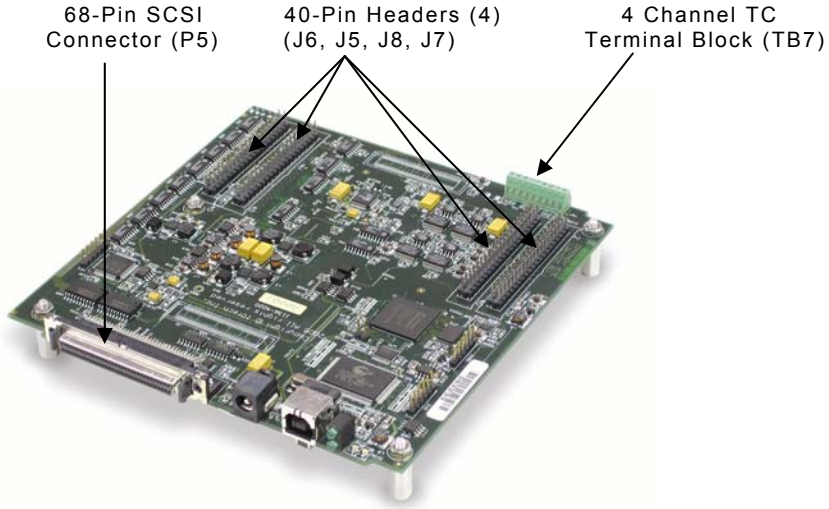
Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

CAUTION

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage. You should always handle components carefully, and you should never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD controlled area. Such guidelines include the use of properly grounded mats and wrist straps, ESD bags and cartons, and related procedures.

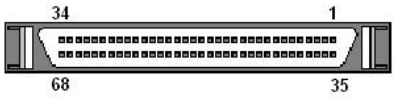
Pinouts for both the TB-100 and the DaqBoard/3000USB Series boards follow. In addition, use of the DBK215 is briefly discussed. Details and specifications for that expansion option are presented in Appendix A.

DaqBoard/3031USB and DaqBoard/3035USB make use of J5 and J6 (two of the four 40-pin headers) for analog expansion. Pinouts for these and the remaining two headers (J7 and J8) are included in this chapter. A pinout for a 4-channel terminal board (TB7) is also included. The last section of the chapter illustrates three scenarios for hardware setup.



Locations of Signal Connectors

68-Pin SCSI Connecter (P5)



WARNING !

Avoid redundant connections. Ensure there is no signal conflict between SCSI pins and the associated header pin (J5. J6. J7. and J8). Also ensure there is no conflict between TB7 (thermocouple connections) and the SCSI and/or the 40-pin headers. Failure to do so could possibly cause equipment damage and/or personal injury.

Pin numbers refer to the 68-pin SCSI female connector, located on the DaqBoard.

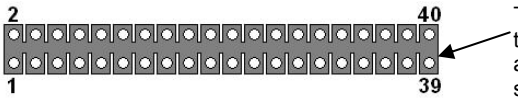
Function	Pin		Pin	Function
Analog input Channel 8	34		68	Analog input Channel 0
Analog input Channel 1	33		67	Analog Common
Analog Common	32		66	Analog input Channel 9
Analog input Channel 10	31		65	Analog input Channel 2
Analog input Channel 3	30		64	Analog Common
Analog Common	29		63	Analog input Channel 11
Analog input Channel 4	28		62	Low Level Sense Common
Analog Common	27		61	Analog input Channel 12
Analog input Channel 13	26		60	Analog input Channel 5
Analog input Channel 6	25		59	Analog Common
Analog Common	24		58	Analog input Channel 14
Analog input Channel 15	23		57	Analog input Channel 7
Analog Output 0 (**DAC0**) Note 1	22		56	Analog Output 3 (**DAC3**) Note 1
Analog Output 1 (**DAC1**) Note 1	21		55	Analog Output 2 (**DAC2**) Note 1
SELFCAL	20		54	Digital Common
Vcc (+5 VDC)	19		53	Digital Common
Digital I/O line A0	18		52	Digital I/O line A1
Digital I/O line A2	17		51	Digital I/O line A3
Digital I/O line A4	16		50	Digital I/O line A5
Digital I/O line A6	15		49	Digital I/O line A7
Digital I/O line B0	14		48	Digital I/O line B1
Digital I/O line B2	13		47	Digital I/O line B3
Digital I/O line B4	12		46	Digital I/O line B5
Digital I/O line B6	11		45	Digital I/O line B7
Digital I/O line C0	10		44	Digital I/O line C1
Digital I/O line C2	9		43	Digital I/O line C3
Digital I/O line C4	8		42	Digital I/O line C5
Digital I/O line C6	7		41	Digital I/O line C7
TTL Trigger Input	6		40	Digital Common
Counter Input CTR0	5		39	Counter Input CTR1
Counter Input CTR2	4		38	Counter Input CTR3
Timer Output 0	3		37	Timer Output 1
A/D Pacer Clock Input/Output	2		36	Digital Common
DAC Pacer Clock I/O	1		35	Digital Common

PORT A **PORT A**
PORT B **PORT B**
PORT C **PORT C**

Note 1: DaqBoard/3001USB and /3031USB each include DAC0, DAC1, DAC2, and DAC3. DaqBoard/3005USB and /3035USB have no DACs.

J5 and J6, 40-Pin Headers for Analog Channels

Note: All channels are available for DaqBoard/3031USB and /3035USB. Channels 16 through 63 are not available for DaqBoard/3001USB and /3005USB.



This edge of the header is closest to the board's center. Note that pins 2 and 40 are labeled on the board silkscreen.

Each 40-pin header can be terminated out to a DB37 male connector via the CA-248 cable.

J5

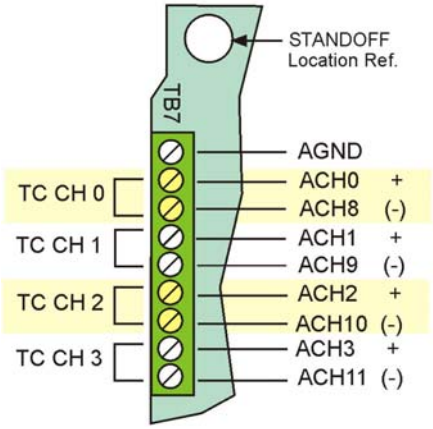
Analog CH.	Pin	Pin	Analog CH.
CH 27	1	2	CH 19
CH 26	3	4	CH 18
Analog Com.	5	6	Analog Com.
CH 3 ⚠	7	8	CH 11 ⚠
CH 2 ⚠	9	10	CH 10 ⚠
CH 17	11	12	CH 25
CH 16	13	14	CH 24
CH 1 ⚠	15	16	CH 9 ⚠
CH 0 ⚠	17	18	CH 8 ⚠
Analog Com.	19	20	Analog Com.
CH 23	21	22	CH 31
CH 22	23	24	CH 30
CH 7	25	26	CH 15
CH 6	27	28	CH 14
Analog Com.	29	30	CH 21
CH 29	31	32	CH 20
CH 28	33	34	CH 5
CH 13	35	36	CH 4
CH 12	37	38	Analog Com.
Analog Com.	39	40	Analog Com.

J6

Analog CH.	Pin	Pin	Analog CH.
CH 43	1	2	CH 59
CH 35	3	4	CH 51
Analog Com.	5	6	CH 58
CH 42	7	8	CH 50
CH 34	9	10	CH 57
Analog Com.	11	12	CH 49
CH 41	13	14	CH 56
CH 33	15	16	CH 48
CH 40	17	18	Analog Com.
CH 32	19	20	CH 63
CH 47	21	22	CH 55
CH 39	23	24	Analog Com.
CH 46	25	26	CH 62
CH 38	27	28	CH 54
Analog Com.	29	30	CH 61
CH 45	31	32	CH 53
CH 37	33	34	CH 60
CH 44	35	36	CH 52
CH 36	37	38	Analog Com.
Analog Com.	39	40	Analog Com.

⚠ **For Analog Channels 0, 1, 2, 3, 8, 9, 10, and 11: Read the following WARNING which applies to their use as thermocouple channels.**

TB7, 4-Channel Thermocouple Terminal Block



WARNING !

Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The TB7 terminal block can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

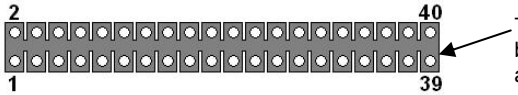
Thermocouples should only be connected in differential mode. Appendix B includes additional information.

DaqBoard/3000USB Series devices do not have open thermocouple detection.

J7 and J8, 40-Pin Headers for

Digital Ports, Counters, Timers, DACS, Triggers, Pacer Clocks and Other Signals

Note: The 4 DAC channels are available for DaqBoard/3001USB and /3031USB. The DACs do not apply to DaqBoard/3005USB and /3035USB.



This edge of the header is closest to the board's center. Note that pins 2 and 40 are labeled on the board silkscreen.

Each 40-pin header can be terminated out to a DB37 male connector via the CA-248 cable.

J7

Digital CH.		Pin	Pin		Digital CH.
Digital GND		1	2		XAPCR *
PORT A	CH A0	3	4		CH A4
	CH A1	5	6		CH A5
	CH A2	7	8		CH A6
	CH A3	9	10		CH A7
Digital GND		11	12		XTTLTRG
PORT B	CH B0	13	14		CH B4
	CH B1	15	16		CH B5
	CH B2	17	18		CH B6
	CH B3	19	20		CH B7
Digital GND		21	22		Exp +5 Volts
PORT C	CH C0	23	24		CH C4
	CH C1	25	26		CH C5
	CH C2	27	28		CH C6
	CH C3	29	30		CH C7
Digital GND		31	32		Timer 1
Timer 0		33	34		Counter 1
Counter 0		35	36		Counter 3
Counter 2		37	38		Digital GND
Digital GND		39	40		Digital GND

* XAPCR = A/D Pacer Clock I/O

J8

Signal	Pin	Pin	Signal
+13VA **(Fig. 1)**	1	2	-13VA **(Fig. 2)**
--X--	3	4	--X--
Analog Com.	5	6	Analog Com.
XDAC0	7	8	XDAC2
XDAC1	9	10	XDAC3
Analog Com.	11	12	Analog Com.
SelfCal **(Fig 3)**	13	14	SGND **
Analog Com.	15	16	Analog Com.
XTTLTRG	17	18	XDPCR ***
XAPCR*	19	20	Digital GND
Digital GND	21	22	Digital GND
--X--	23	24	--X--
Exp. +5 Volts	25	26	Aux Pwr **(Fig. 4)**
--X--	27	28	--X--
--X--	29	30	--X--
--X--	31	32	--X--
--X--	33	34	--X--
--X--	35	36	--X--
--X--	37	38	--X--
--X--	39	40	--X--

-- *X*-- = Not Connected

** SGND = Signal Ground (Low Level Sense Common)

*** XDPCR = DAC Pacer Clock I/O

J8 Pinout Figure References for Pins 1, 2, 13, and 26

Figure 1. J8 / Pin 1, for +13VA

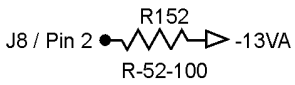


Figure 2. J8 / Pin 2, for -13VA

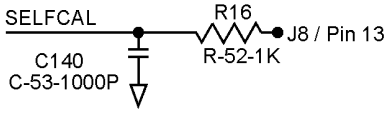
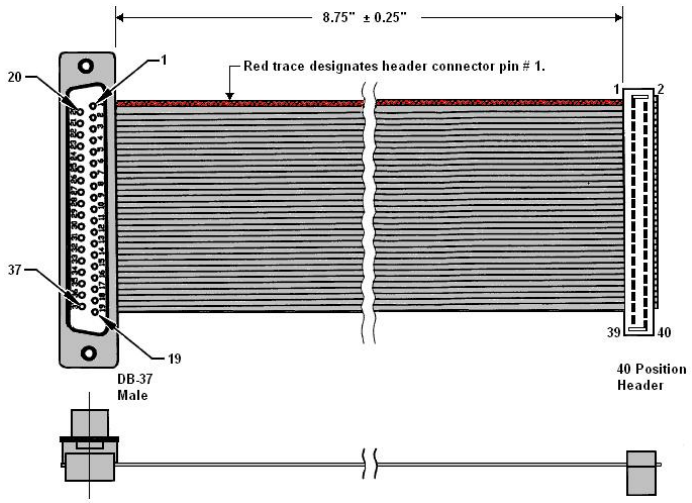


Figure 3. J8 / Pin 13, for Self Calibration

Figure 4. J8 / Pin 26, for Auxiliary Power

CA-248, 40-Position Header to DB-37 Male, Ribbon Cable



CA-248 Pinout, DB-37 Pins listed Sequentially

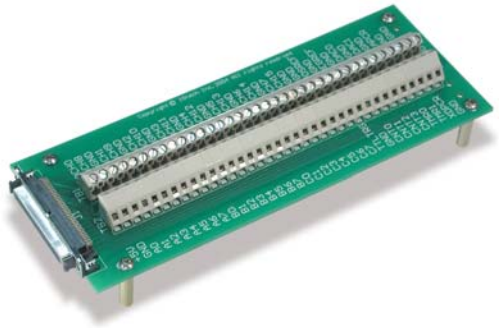
DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.
1	1		11	21		21	4		31	24
2	3		12	23		22	6		32	26
3	5		13	25		23	8		33	28
4	7		14	27		24	10		34	30
5	9		15	29		25	12		35	32
6	11		16	31		26	14		36	34
7	13		17	33		27	16		37	36
8	15		18	35		28	18		---	---
9	17		19	37		29	20		---	---
10	19		20	2		30	22		---	---

CA-248 Pinout, 40 Position Header Pins listed Sequentially

DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.		DB37 Pin No.	40 Position Header Pin No.
1	1		6	11		11	21		16	31
20	2		25	12		30	22		35	32
2	3		7	13		12	23		17	33
21	4		26	14		31	24		36	34
3	5		8	15		13	25		18	35
22	6		27	16		32	26		37	36
4	7		9	17		14	27		19	37
23	8		28	18		33	28		---	38
5	9		10	19		15	29		---	39
24	10		29	20		34	30		---	40

TB-100 Terminal Connector Option

The TB-100 Terminal Connector option can be used to connect all signal I/O lines that are associated with a DaqBoard/3000USB Series device. TB-100 connects to the DaqBoard's 68-pin SCSI connector via a 68-conductor cable: p/n CA-G55, CA-G56, or CA-G56-6.



TB-100 Pinout				The "Pin" column refers to the pin no. on the 68-Pin SCSI Connector.		
Screw Terminals for TB2 Side		**Pin**		**Screw Terminals for TB1 Side**		**Pin**
+5V	Vcc (+5 VDC)	19		ACH0	Analog Input Channel 0	68
GND	Digital Common	Note 1		ACH8	Analog Input Channel 8	34
A0	Digital I/O Line A0	18		AGND	Analog Common	Note 2
A1	Digital I/O Line A1	52		ACH1	Analog Input Channel 1	33
A2	Digital I/O Line A2	17		ACH9	Analog Input Channel 9	66
A3	Digital I/O Line A3	51		AGND	Analog Common	Note 2
A4	Digital I/O Line A4	16		ACH2	Analog Input Channel 2	65
A5	Digital I/O Line A5	50		ACH10	Analog Input Channel 10	31
A6	Digital I/O Line A6	15		AGND	Analog Common	Note 2
A7	Digital I/O Line A7	49		ACH3	Analog Input Channel 3	30
B0	Digital I/O Line B0	14		ACH11	Analog Input Channel 11	63
B1	Digital I/O Line B1	48		AGND	Analog Common	Note 2
B2	Digital I/O Line B2	13		ACH4	Analog Input Channel 4	28
B3	Digital I/O Line B3	47		ACH12	Analog Input Channel 12	61
B4	Digital I/O Line B4	12		AGND	Analog Common	Note 2
B5	Digital I/O Line B5	46		ACH5	Analog Input Channel 5	60
B6	Digital I/O Line B6	11		ACH13	Analog Input Channel 13	26
B7	Digital I/O Line B7	45		AGND	Analog Common	Note 2
C0	Digital I/O Line C0	10		ACH6	Analog Input Channel 6	25
C1	Digital I/O Line C1	44		ACH14	Analog Input Channel 14	58
C2	Digital I/O Line C2	9		AGND	Analog Common	Note 2
C3	Digital I/O Line C3	43		ACH7	Analog Input Channel 7	57
C4	Digital I/O Line C4	8		ACH15	Analog Input Channel 15	23
C5	Digital I/O Line C5	42		XDAC3	Analog Output, **DAC3**	56
C6	Digital I/O Line C6	7		SGND	Low Level Sense Common	62
C7	Digital I/O Line C7	41		POSREF	+5 VDC Positive Reference	20
TTLTRG	TTL Trigger Input	6		XDAC2	Analog Output, **DAC2**	55
GND	Digital Common	Note 1		NEGREF	- 5 VDC Negative Reference	54
CNT0	Counter Input CTR0	5		AGND	Analog Common	Note 2
CNT1	Counter Input CTR1	39		XDAC0	Analog Output, **DAC0**	22
CNT2	Counter Input CTR2	4		AGND	Analog Common	Note 2
CNT3	Counter Input CTR3	38		XDAC1	Analog Output, **DAC1**	21
TMR0	Timer Output 0	3		AGND	Analog Common	Note 2
TMR1	Timer Output 1	37		XAPCR	A/D Pacer Clock I/O	2
XDPCR	DAC Pacer Clock I/O	1		GND	Digital Common	Note 1
GND	Digital Common	Note 1		EGND	Earth Ground	N/A

Note 1: Digital Common Pins on the SCSI connector are: 35, 36, and 40.

Note 2: Analog Common Pins on the SCSI connector are: 24, 27, 29, 32, 59, 64, and 67

TB-101 Terminal Board Option

The TB-101 Terminal Board can be used to connect all signal I/O lines that are associated with a DaqBoard/3000USB Series board. TB-101 plugs into the DaqBoard's four 40-pin headers (J5, J6, J7, and J8). For purpose of orientation, the notch (following figure, upper left) fits over TB7 on the DaqBoard/3000USB.

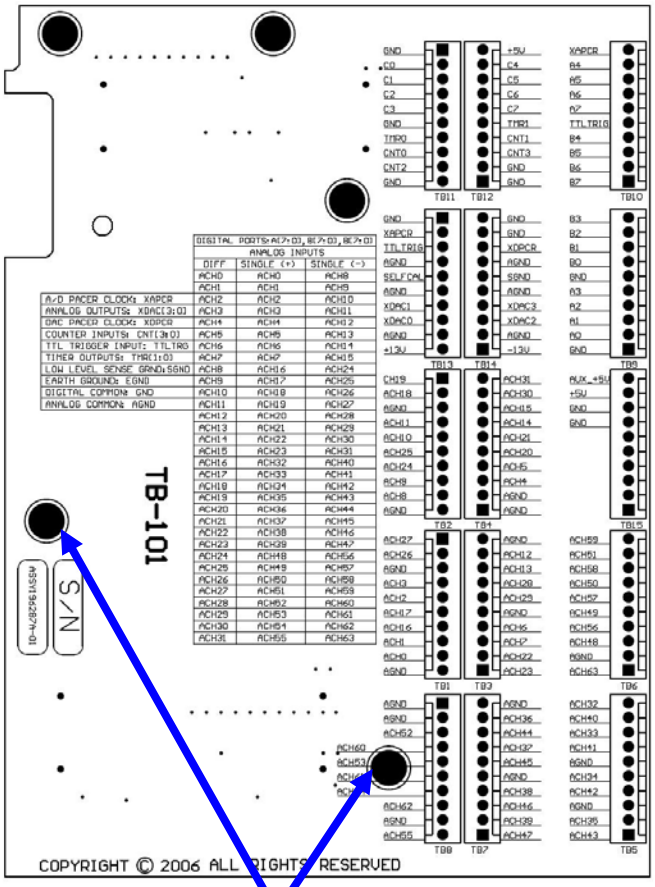
WARNING !

Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

Avoid redundant connections. Ensure there is no signal conflict between SCSI pins and the 15 terminal blocks of TB-101 [which relate to J5, J6, J7, and J8 on the main board]. Also ensure there is no conflict between the main board's TB7 connector and the SCSI and/or the Terminal blocks of TB-101. Failure to do so could possibly cause equipment damage and/or personal injury.

CAUTION

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage. You should always handle components carefully, and you should never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD controlled area. Such guidelines include the use of properly grounded mats and wrist straps, ESD bags and cartons, and related procedures.



Standoff Locations, 5 in Total

How to Mount the TB-101

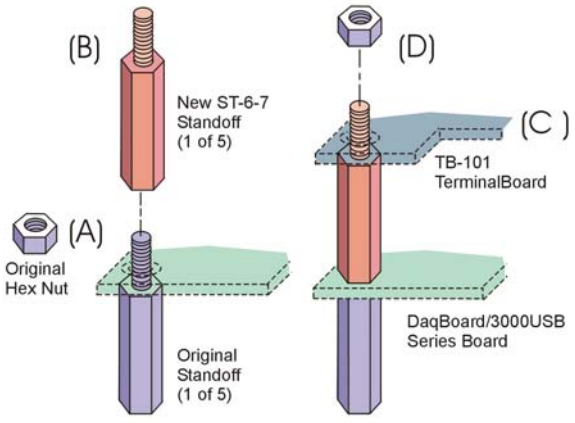
(Steps A through D refer to the following illustration)

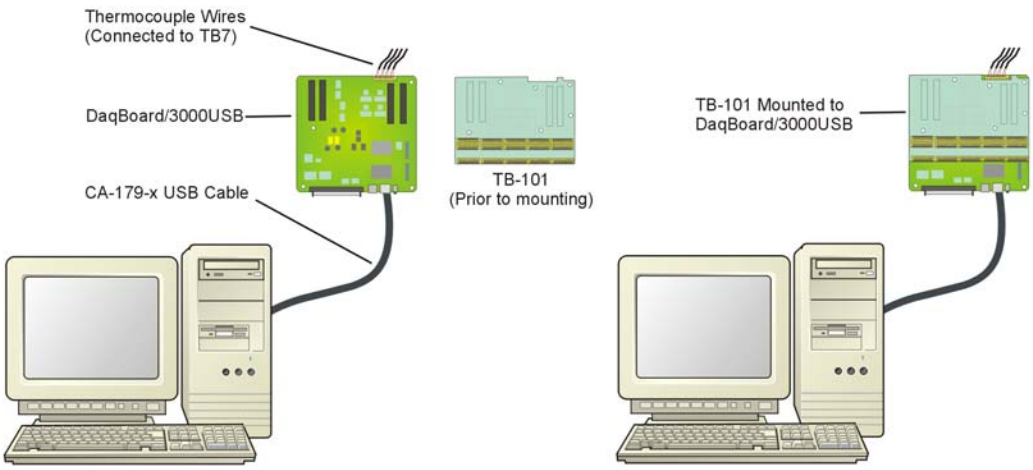
A – After taking ESD precautions, remove the Hex Nuts from the 5 existing standoffs.

B – Thread the new ST-6-7 standoffs onto the existing standoffs. Tighten snug by hand.

C – Align the TB-101 with the new standoffs and position the board in place.

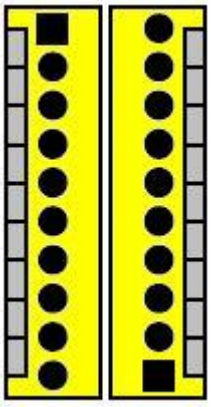
D – Using the Hex Nuts (removed in Step A), secure the TB-101 to the new standoffs. Tighten snug. Over-tighten will damage the board.





TB-101 Mounting Concept

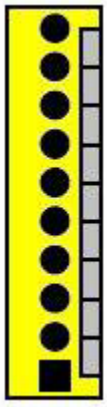
TB-101 Pinouts



Digital GND	Expansion +5V
CH C0, Digital	CH C4, Digital
CH C1, Digital	CH C5, Digital
CH C2, Digital	CH C6, Digital
CH C3, Digital	CH C7, Digital
Digital GND	Timer 1 (TMR1)
Timer 0 (TMR0)	Counter 1 (CNT1)
Counter 0 (CNT0)	Counter 3 (CNT3)
Counter 2 (CNT2)	Digital GND
Digital GND	Digital GND

TB11 TB12

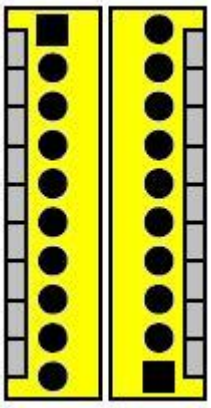
TB11 is associated with J7, odd # pins 21 through 39 on the main board.
TB12 is associated with J7, even # pins 22 through 40 on the main board.



XAPCR (Note 1)
CH A4, Digital
CH A5, Digital
CH A6, Digital
CH A7, Digital
TTLTRIG
CH B4, Digital
CH B5, Digital
CH B6, Digital
CH B7, Digital

TB10

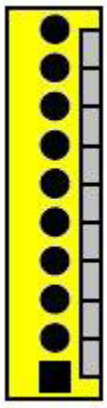
TB10 is associated with J7, even # pins 2 through 20 on the main board.



Digital GND	Digital GND
XAPCR (Note 1)	Digital GND
XTTLTRG	XDPCR (Note 2)
Analog Common	Analog Common
Self Calibration	SGND
Analog Common	Analog Common
XDAC1 (Note 3)	XDAC3 (Note 3)
XDAC0 (Note 3)	XDAC2 (Note 3)
Analog Common	Analog Common
+ 13V	-13V

TB13 TB14

TB13 is associated with J8, odd # pins 1 through 21 on the main board.
TB14 is associated with J8, even # pins 2 through 22 on the main board.



CH B3, Digital
CH B2, Digital
CH B1, Digital
CH B0, Digital
Digital GND
CH A3, Digital
CH A2, Digital
CH A1, Digital
CH A0, Digital
Digital GND

TB9

TB10 is associated with J7, odd # pins 1 through 19 on the main board.

Note 1: XAPCR is A/D Pacer Clock I/O.

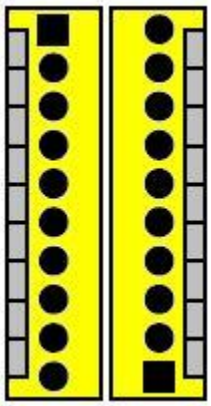
Note 2: XDPCR is DAC Pacer Clock I/O.

Note 3: XDAC0 / 1/ 2 / 3 analog outputs only apply to the DaqBoard/3001USB and /3031USB model boards.

WARNING !

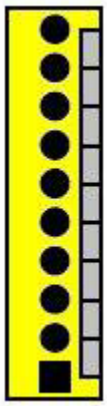
Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The analog channels associated with thermocouples are:
TB1: Channels 0, 1, 2, and 3
TB2: Channels 8, 9, 10, and 11.



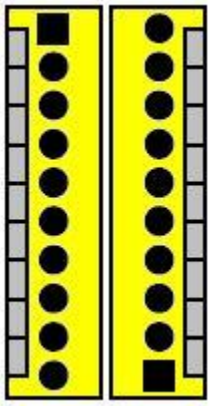
TB2	TB4
CH 19, Analog	CH 31, Analog
CH 18, Analog	CH 30, Analog
Analog Com.	CH 15, Analog
CH 11, Analog	CH 14, Analog
CH 10, Analog	CH 21, Analog
CH 25, Analog	CH 20, Analog
CH 24, Analog	CH 5, Analog
CH 9, Analog	CH 4, Analog
CH 8, Analog	Analog Common
Analog Com.	Analog Common

TB2 is associated with J5, even # pins 2 through 20 on the main board.
TB4 is associated with J5, even # pins 22 through 40 on the main board.



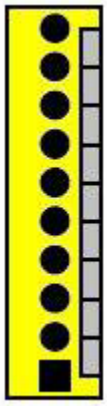
TB15	
Aux +5 V	
Expansion +5 V	
Digital GND	
Digital GND	
-- no connection --	
-- no connection --	
-- no connection --	
-- no connection --	
-- no connection --	
-- no connection --	

TB15 is not directly associated with pins on the main board.



TB1	TB3
CH 27, Analog	Analog Com.
CH 26, Analog	CH 12, Analog
Analog Com.	CH 13, Analog
CH 3, Analog	CH 28, Analog
CH 2, Analog	CH 29, Analog
CH 17, Analog	Analog Com.
CH 16, Analog	CH 6, Analog
CH 1, Analog	CH 7, Analog
CH 0, Analog	CH 22, Analog
Analog Com.	CH 23, Analog

TB1 is associated with J5, odd # pins 1 through 19 on the main board.
TB3 is associated with J5, odd # pins 21 through 39 on the main board.



TB6
CH 59, Analog
CH 51, Analog
CH 58, Analog
CH 50, Analog
CH 57, Analog
CH 49, Analog
CH 56, Analog
CH 48, Analog
Analog Common
CH 63, Analog

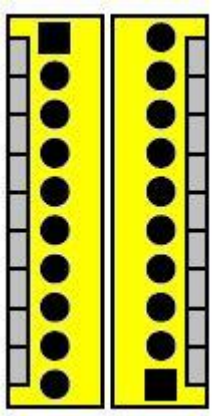
TB6 is associated with J6, even # pins 2 through 20 on the main board.

Regarding Analog Input Channels **for DaqBoard/3001USB** and **DaqBoard/3005USB**
Single Ended - only analog channels 0 through 15 apply.
Differential - only analog channels 0 through 7 apply.

Regarding Analog Input Channels **for DaqBoard/3031USB** and **DaqBoard/3035USB**
Single Ended - analog channels 0 through 63 apply.
Differential - analog channels 0 through 31 apply.

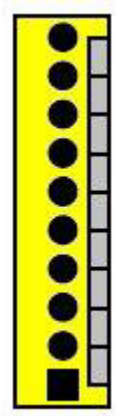
(Continued)

Analog Common	1	2	Analog Common	CH 32, Analog	1	2	CH 40, Analog
Analog Common	3	4	CH 36, Analog	CH 33, Analog	3	4	CH 41, Analog
CH 52, Analog	5	6	CH 44, Analog	Analog Common	5	6	CH 34, Analog
CH 60, Analog	7	8	CH 37, Analog	CH 42, Analog	7	8	Analog Common
CH 53, Analog	9	10	CH 45, Analog	Analog Common	9	10	CH 35, Analog
CH 61, Analog	11	12	Analog Common	CH 43, Analog			
CH 54, Analog	13	14	CH 38, Analog				
CH 62, Analog	15	16	CH 46, Analog				
Analog Common	17	18	CH 39, Analog				
CH 55, Analog	19	20	CH 47, Analog				



TB8 **TB7**

TB8 is associated with J6, even # pins 22 through 40 on the main board.
TB7 is associated with J6, odd # pins 21 through 39 on the main board.



TB5

TB5 is associated with J6, odd # pins 1 through 19 on the main board.

TB-101 Differential Connections; 32 Differential Channels

ANALOG CHANNELS

Differential Channel #	High (+)	Low (-)
CH 0	CH 0	CH 8
CH 1	CH 1	CH 9
CH 2	CH 2	CH 10
CH 3	CH 3	CH 11
CH 4	CH 4	CH 12
CH 5	CH 5	CH 13
CH 6	CH 6	CH 14
CH 7	CH 7	CH 15
CH 8	CH 16	CH 24
CH 9	CH 17	CH 25
CH 10	CH 18	CH 26
CH 11	CH 19	CH 27
CH 12	CH 20	CH 28
CH 13	CH 21	CH 29
CH 14	CH 22	CH 30
CH 15	CH 23	CH 31

ANALOG CHANNELS

Differential Channel #	High (+)	Low (-)
CH 16	CH 32	CH 40
CH 17	CH 33	CH 41
CH 18	CH 34	CH 42
CH 19	CH 35	CH 43
CH 20	CH 36	CH 44
CH 21	CH 37	CH 45
CH 22	CH 38	CH 46
CH 23	CH 39	CH 47
CH 24	CH 48	CH 56
CH 25	CH 49	CH 57
CH 26	CH 50	CH 58
CH 27	CH 51	CH 59
CH 28	CH 52	CH 60
CH 29	CH 53	CH 61
CH 30	CH 54	CH 62
CH 31	CH 55	CH 63

Regarding Analog Input Channels **for DaqBoard/3001USB** and **DaqBoard/3005USB**
Single Ended - only analog channels 0 through 15 apply.
Differential - only analog channels 0 through 7 apply.

Regarding Analog Input Channels **for DaqBoard/3031USB** and **DaqBoard/3035USB**
Single Ended - analog channels 0 through 63 apply.
Differential - analog channels 0 through 31 apply.

DBK215 16-Connector BNC Connection Module Option

DBK215

If you are not using a TB-100 terminal board connection option with your DaqBoard/3000USB Series board you can, instead, make use of a DBK215 module. The DBK215 includes:

- BNC Access to 16 inputs or outputs (on front panel)
- on-board screw-terminal blocks*
- on-board socket locations for custom RC Filter networks*
- 68-pin SCSI connector (on rear panel)

* The top cover plate must be removed to access the terminal blocks and the RC filter network section of the DBK215's board.

The 68-pin SCSI connector (P5) connects to the DaqBoard/3000USB Series board's 68-pin SCSI connector via a CA-G55, CA-G56, or CA-G56-6 cable.

The DBK215 provides BNC and screw-terminal access to all analog and digital I/O from the host data acquisition device. Related to the screw-terminals is a front panel slot for routing all I/O wiring.

Reference Notes:
For details regarding the DBK215, refer to Appendix A.

Hardware Setups

This section presents three examples of hardware setup. Other scenarios are possible, for example, using a TB-100 and also using one CA-248 cable. Users may also forgo the use of TB7, even if using thermocouples. Also note that the optional TR-2 power supply can be used in any scenario.

The most important part of the setup is to avoid making redundant signal connections and to use approved ESD precautions. Pinouts are presented earlier in this chapter.

WARNING !

Avoid redundant connections. Ensure there is no signal conflict between SCSI pins and the associated header pin (J5. J6. J7. and J8). Also ensure there is no conflict between TB7 (thermocouple connections) and the SCSI and/or the 40-pin headers. Failure to do so could possibly cause equipment damage and/or personal injury.

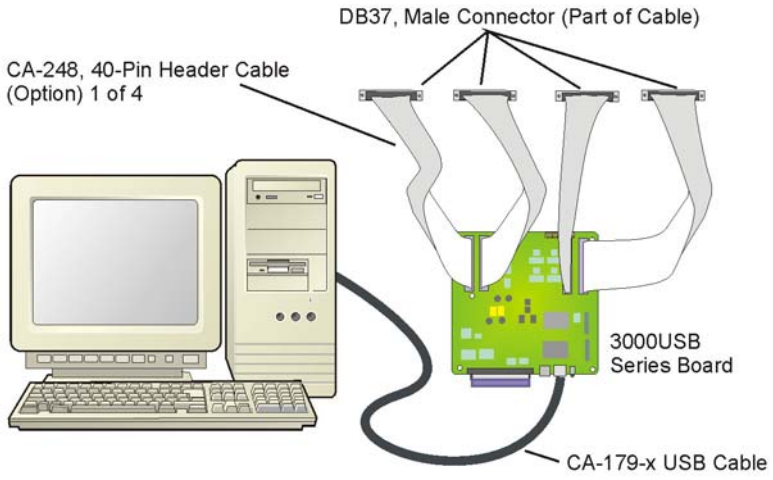
WARNING !

Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

CAUTION

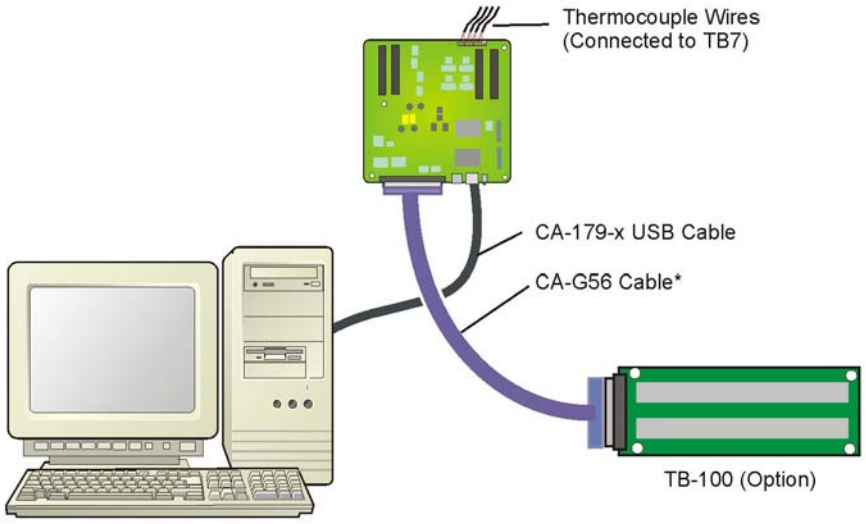
The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage. You should always handle components carefully, and you should never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD controlled area. Such guidelines include the use of properly grounded mats and wrist straps, ESD bags and cartons, and related procedures.

Scenario 1: Using CA-248 Cables to obtain DB37 Connectors

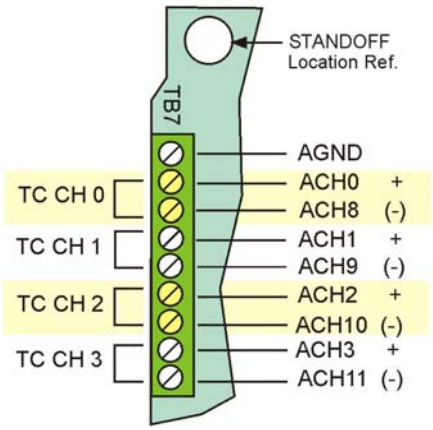


In this setup a CA-248 cable is connected to each of the 40-pin headers (J5, J6, J7, and J8). The result is four male DB37 connectors which, as can be seen from the pinouts, offer the same signal connectivity as the SCSI connector. Note that the J6 header is dedicated entirely to analog expansion and therefore is not applicable to /3001USB or /3005USB. As in all scenarios, a CA-179-x USB cable is used to connect the /3000USB Series board to a USB2.0 port on the host PC.

Scenario 2: Using a TB-100



In this setup a TB-100 screw-terminal board option is connected to the 68-pin SCSI connector via a CA-G56 shielded cable. However, the use of other cables is possible as noted below. In this example we can also see that 4 thermocouples are connected at TB7 (on the /3000USB board). This means that 8 analog channels [to obtain 4 differential TC channels] are required (see following figure). Redundant connections must be avoided.



WARNING !

Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The TB7 terminal block can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

Thermocouples should only be connected in differential mode. Appendix B includes additional information.

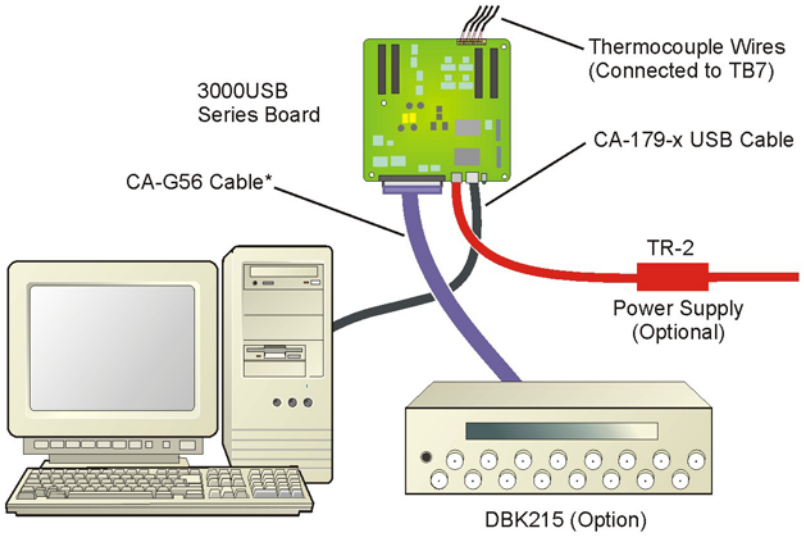
DaqBoard/3000USB Series devices do not have open thermocouple detection.

As in all scenarios, a CA-179-x USB cable is used to connect the /3000USB Series board to a USB2.0 port on the host PC.

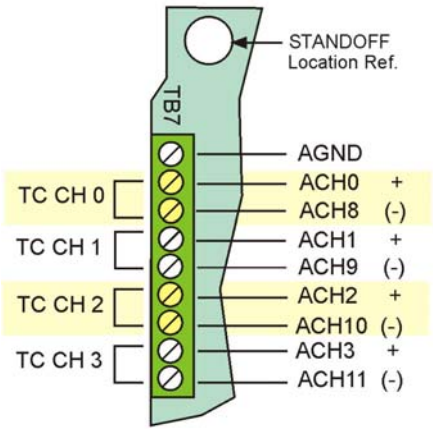
* Any of the following 68-conductor expansion cables can be used to connect the TB-100 option the SCSI connector:

CA-G55	3 feet, ribbon cable.
CA-G56	3 feet, shielded expansion cable.
CA-G56-6	6 feet, shielded expansion cable.

Scenario 3: Using a DBK215



In this setup a DBK215 BNC Module is connected to the 68-pin SCSI connector via a CA-G56 shielded cable. However, the use of other cables is possible as noted below. In this example we can also see that 4 thermocouples are connected at TB7 (on the /3000USB board). This means that 8 analog channels [to obtain 4 differential TC channels] are required (see following figure). Redundant connections must be avoided. A TR-2 power supply is being used, and is connected to the board's external power connector.



WARNING !

Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The TB7 terminal block can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

Thermocouples should only be connected in differential mode. Appendix B includes additional information.

DaqBoard/3000USB Series devices do not have open thermocouple detection.

As in all scenarios, a CA-179-x USB cable is used to connect the /3000USB Series board to a USB2.0 port on the host PC.

* Any of the following 68-conductor expansion cables can be used to connect the DBK215 module option the SCSI connector:

CA-G55	3 feet, ribbon cable.
CA-G56	3 feet, shielded expansion cable.
CA-G56-6	6 feet, shielded expansion cable.

CE-Compliance 3

Overview ……3-1
CE Standards and Directives …… 3-1
Safety Conditions ……3-2
Emissions/Immunity Conditions ……3-2

Overview

CE standards were developed by the European Union (EU) dating from 1985 and include specifications both for safety and for EMI emissions and immunity. Now, all affected products sold in EU countries must meet such standards. Although not required in the USA, these standards are considered good engineering practice since they enhance safety while reducing noise and ESD problems.

In contracted and in-house testing, most Daq products met the required specifications. Those products not originally in compliance were redesigned accordingly. In some cases, alternate product versions, shield plates, edge guards, special connectors, or add-on kits are required to meet CE compliance.

CE-compliant products bear the "CE" mark and include a *Declaration of Conformity* stating the particular specifications and conditions that apply. The test records and supporting documentation that validate the compliance are kept on file at the factory.

CE Standards and Directives

The electromagnetic compatibility (EMC) directives specify two basic requirements:

1. The device must not interfere with radio or telecommunications.
2. The device must be immune from electromagnetic interference from RF transmitters, etc.

The standards are published in the *Official Journal of European Union* under direction of CENELEC (European Committee for Electrotechnical Standardization). The specific standards relevant to Daq equipment are listed on the product's Declaration of Conformity and include: CISPR22:1985; EN55022:1988 (Information Technology Equipment, Class A for commercial/industrial use); and EN50082-1:1992 for various categories of EMI immunity.

The safety standard that applies to Daq products is EN 61010-1 : 1993 (*Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements*). Environmental conditions include the following:

- indoor use
- altitude up to 2000 m
- temperature 5°C to 40°C (41°F to 104°F)
- maximum relative humidity 80% for temperatures up to 31°C (87.8°F) decreasing linearly to 50% relative humidity at 40°C (104°F)
- mains supply voltage fluctuations not to exceed ±10% of the nominal voltage
- other supply voltage fluctuations as stated by the manufacturer
- transient overvoltage according to installation categories (overvoltage categories) I, II and III For mains supply, the minimum and normal category is II
- pollution degree I or II in accordance with IEC 664

For clarification, terms used in some Declarations of Conformity include:

- **pollution degree**: any addition of foreign matter, solid, liquid or gaseous (ionized gases) that may produce a reduction of dielectric strength or surface resistivity. **Pollution Degree I** has no influence on safety and implies: the equipment is at operating temperature with non-condensing humidity conditions; no conductive particles are permitted in the atmosphere; warm-up time is sufficient to avert any condensation or frost; no hazardous voltages are applied until completion of the warm-up period. **Pollution Degree II** implies the expectation of occasional condensation.
- **overvoltage (installation) category**: classification with limits for transient overvoltage, dependent on the nominal line voltage to earth. **Category I** implies signals without high transient values. **Category II** applies to typical mains power lines with some transients.

Safety Conditions

Users must comply with all relevant safety conditions in the user's manual and the Declarations of Conformity. This manual and Daq hardware make use of the following Warning and Caution symbols: If you see either of these symbols on a product, carefully read the related information and be alert to the possibility of personal injury.

This warning symbol is used in this manual or on the equipment to warn of possible injury or death from electrical shock under noted conditions.

This warning/caution symbol is used to warn of possible personal injury or equipment damage under noted conditions.

Daq products contain no user-serviceable parts; refer all service to qualified personnel. The specific safety conditions for CE compliance vary by product; but general safety conditions include:

- The operator must observe all safety cautions and operating conditions specified in the documentation for all hardware used.
- The host computer and all connected equipment must be CE compliant.
- All power must be off to the device and externally connected equipment before internal access to the device is permitted.
- Isolation voltage ratings: do not exceed documented voltage limits for power and signal inputs. All wire insulation and terminal blocks in the system must be rated for the isolation voltage in use. Voltages above 30 Vrms or ±60 VDC must not be applied if any condensation has formed on the device.
- Current and power use must not exceed specifications. Do not defeat fuses or other over-current protection.

Emissions/Immunity Conditions

The specific immunity conditions for CE compliance vary by product; but general immunity conditions include:

- Cables must be shielded, braid-type with metal-shelled connectors. Input terminal connections are to be made with shielded wire. The shield should be connected to the chassis ground with the hardware provided.
- The host computer must be properly grounded.
- In low-level analog applications, some inaccuracy is to be expected when I/O leads are exposed to RF fields or transients over 3 or 10 V/m as noted on the Declaration of Conformity.

Calibration 4

The DaqCal.exe calibration utility does not support DaqBoard/3000USB Series boards at present. Please contact the factory for the latest calibration information concerning these products.

Every range of a DaqBoard/3000USB board is calibrated at the factory using a digital NIST traceable calibration method. This method works by storing a correction factor for each range on the unit at the time of calibration. The user can adjust the calibration of the board while it is installed in the acquisition system without destroying the factory calibration. This is accomplished by having 3 distinct calibration tables in the on-board EPROM.

The user can select any of the three cal tables provided [factory, user, or self-cal tables] by API call or from within software. Self-cal can be performed automatically via the included software and without the use of external hardware or instruments. Self-cal derives its tracebility through an on-board reference which has a stability of 0.005% per year.

Note that a 2-year calibration period is recommended for /3000USB Series boards.

Using a Temperature Calibrator

DaqBoard/3000USB boards provide accurate and repeatable temperature measurements across a wide range of operating conditions. However, all instrumentation is subject to drift with time and with ambient temperature change. If the ambient temperature of the operating environment is below 18°C or above 28°C, or if the product is near or outside its calibration interval, then the absolute accuracy may be improved through the use of an external temperature calibrator.

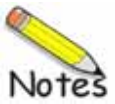
A temperature calibrator is a temperature simulation instrument that allows selection of thermocouple type and temperature. For proper operation, it must be connected to the /3000USB Series board with the same type thermocouple wire and connector that is used in normal testing. The calibrator then generates and supplies a voltage corresponding to that which would be generated by the TC type [at the associated temperature].

The temperature selected on the calibrator will be dictated by the nature of normal testing. 0°C is usually the best choice. Calibrators are the most accurate at this setting, and the connecting thermocouple wire will contribute very little error at this temperature. However, if the dynamic range of the normal testing is, for example, 100°C to 300°C, a selection of 200°C may give better results. In either case, the level of adjustment is determined by comparing the unit reading to the selected calibrator temperature. For example, if the calibrator is set to 0°C output, and the board reads 0.3°C, then an adjustment of *minus* 0.3°C is required. That is, the adjustment value is determined by subtracting the board's reading from the calibrator setting.

To implement the adjustment in DaqView:

1. Ensure that the acquisition process is turned off.
2. Click on the cell in the Units column for the channel that is connected to the calibrator. The engineering units pull-down menu above the grid becomes active.
3. Click on the down arrow and select the "mx+b" option. This option allows post-acquisition mathematical manipulation.
4. For the example adjustment, enter -0.3 for "b." The channel under calibration will now read 0°C.

Note that this adjustment is a mathematical operation only, and in no way alters the board's hardware calibration. Moreover, it operates on a per channel basis, with the settings for a given channel having no influence on any other channels.


Notes

Counter Input Modes 5

***Tips for Making High-Speed Counter Measurements* (> 1 MHz) …… 5-1**

Debounce Module …… 5-1

Terms Applicable to Counter Modes…….5-5

Counter Options …… 5-5

Counter/Totalize Mode …… 5-6

Period Mode …… 5-8

Pulsewidth Mode …… 5-11

Timing Mode …… 5-13

Encoder Mode …… 5-15

Note: Each of the high-speed, 32-bit counter channels can be configured for counter, period, pulse width, time between edges, or encoder modes.

Tips for Making High-Speed Counter Measurements (> 1 MHz)

- Use coax or twisted-pair wire. Connect one side to Digital Common.
- If the frequency source is tolerant, parallel-terminate the coax (or twisted-pair) with a 50 ohm or 100 ohm resistor at the terminal block.
- The amplitude of the driving waveform should be as high as possible without violating the over-voltage specification.
- To ensure adequate switching, waveforms should swing at least 0V to 5V and have a high slew rate.

Debounce

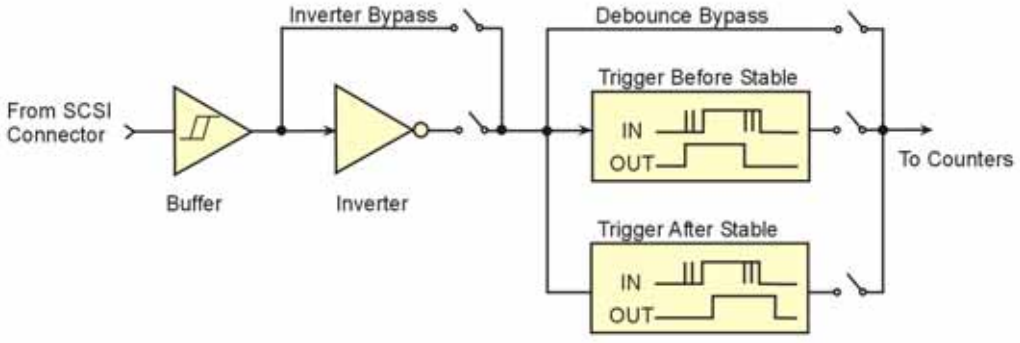
Each channel's output can be debounced with 16 programmable debounce times from 500 ns to 25.5 ms. The debounce circuitry eliminates switch-induced transients typically associated with electro-mechanical devices including relays, proximity switches, and encoders.

From the following illustration we can see that there are two debounce modes, as well as a debounce bypass. In addition, the signal from the buffer can be inverted before it enters the debounce circuitry. The inverter is used to make the input rising-edge or falling-edge sensitive.

Edge selection is available with or without debounce. In this case the debounce time setting is ignored and the input signal goes straight from the inverter [or inverter bypass] to the counter module.

There are 16 different debounce times. In either debounce mode, the debounce time selected determines how fast the signal can change and still be recognized.

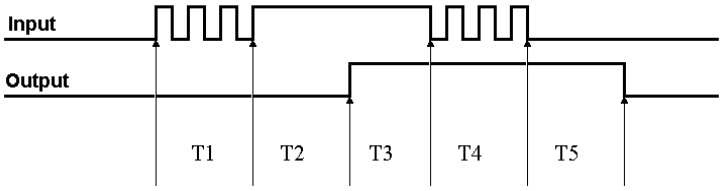
The two debounce modes are "trigger after stable" and "trigger before stable." A discussion of the two modes follows.



Debounce Model

Trigger After Stable Mode

In the "Trigger After Stable" mode, the output of the debounce module will not change state until a period of stability has been achieved. This means that the input has an edge and then must be stable for a period of time equal to the debounce time.



Debounce Module – Trigger After Stable Mode

The following time periods (T1 through T5) pertain to the above drawing. In Trigger After Stable mode, the input signal to the debounce module is required to have a period of stability after an incoming edge, in order for that edge to be accepted (passed through to the counter module.) The debounce time for this example is equal to T2 and T5.

T1 – In the example above, the input signal goes high at the beginning of time period T1 but never stays high for a period of time equal to the debounce time setting (equal to T2 for this example.)

T2 – At the end of time period T2, the input signal has transitioned high and stayed there for the required amount of time, therefore the output transitions high. If the Input signal never stabilized in the high state long enough, no transition would have appeared on the output and the entire disturbance on the input would have been rejected.

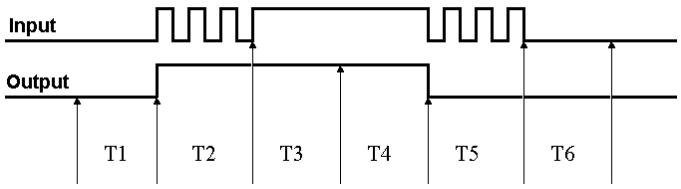
T3 – During time period T3 the input signal remained steady. No change in output is seen.

T4 – During time period T4, the input signal has more disturbances and does not stabilize in any state long enough. No change in the output is seen.

T5 – At the end of time period T5, the input signal has transitioned low and stayed there for the required amount of time, therefore the output goes low.

Trigger Before Stable Mode

In the "Trigger Before Stable" mode, the output of the debounce module immediately changes state, but will not change state again until a period of stability has passed. For this reason the mode can be used to detect glitches.



Debounce Module – Trigger Before Stable Mode

The following time periods (T1 through T6) pertain to the above drawing.

T1 – In the illustrated example, the **Input** signal is low for the debounce time (equal to T1); therefore when the input edge arrives at the end of time period T1 it is accepted and the **Output** (of the debounce module) goes high. Note that a period of stability must precede the edge in order for the edge to be accepted.

T2 – During time period T2, the input signal is not stable for a length of time equal to T1 (the debounce time setting for this example.) Therefore, the output stays "high" and does not change state during time period T2.

T3 – During time period T3, the input signal is stable for a time period equal to T1, meeting the debounce requirement. The output is held at the high state. This is the same state as the input.

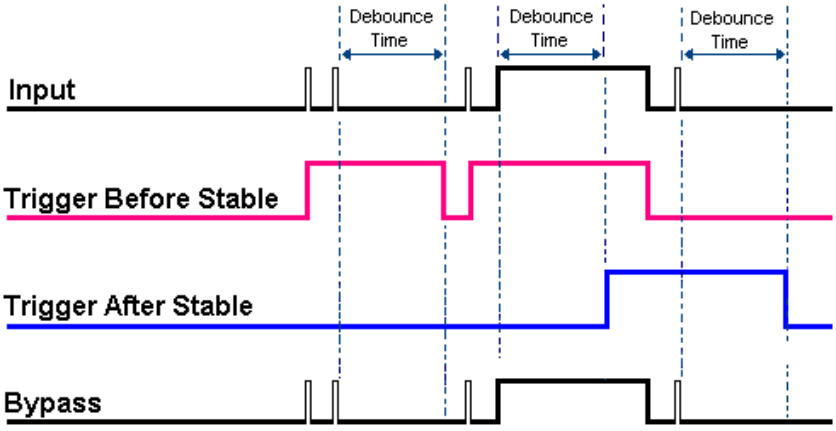
T4 – At anytime during time period T4, the input can change state. When this happens, the output will also change state. At the end of time period T4, the input changes state, going low, and the output follows this action [by going low].

T5 – During time period T5, the input signal again has disturbances that cause the input to not meet the debounce time requirement. The output does not change state.

T6 – After time period T6, the input signal has been stable for the debounce time and therefore any edge on the input after time period T6 will be immediately reflected in the output of the debounce module.

Mode Comparison

The following example shows how the two modes interpret the same input signal (which exhibits glitches). Notice that the *Trigger Before Stable* mode will recognize more glitches than the *Trigger After Stable* mode. Use the *bypass* option to achieve maximum glitch recognition.

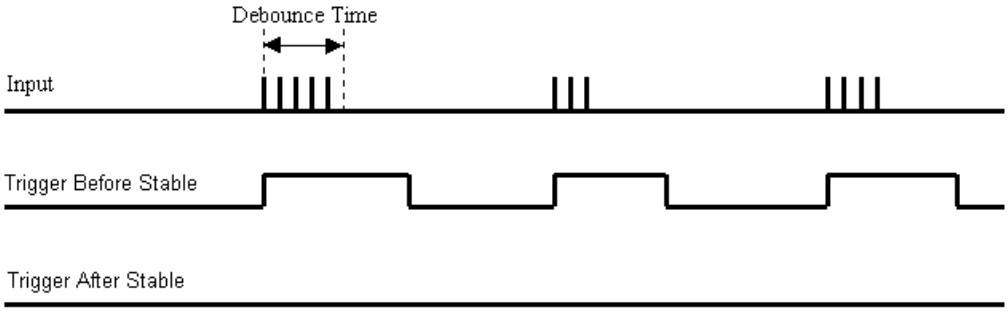


Example of Two Debounce Modes Interpreting the Same Signal

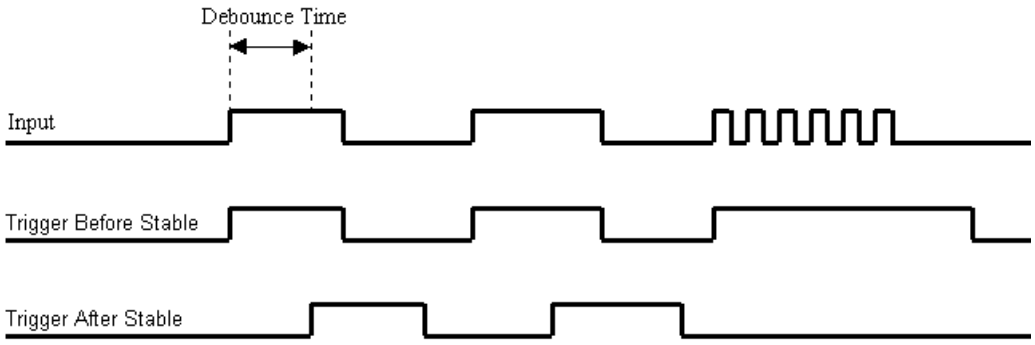
Debounce times should be set according to the amount of instability expected in the input signal. Setting a debounce time that is too short may result in unwanted glitches clocking the counter. Setting a debounce time too long may result in an input signal being rejected entirely. Some experimentation may be required to find the appropriate debounce time for a particular application.

To see the effects of different debounce time settings, simply view the analog waveform along with the counter output. This can be done by connecting the source to an analog input.

Use trigger before stable mode when the input signal has groups of glitches and each group is to be counted as one. The trigger before stable mode will recognize and count the first glitch within a group but reject the subsequent glitches within the group if the debounce time is set accordingly. The debounce time should be set to encompass one entire group of glitches as shown in the following diagram.



Trigger after stable mode behaves more like a traditional debounce function: rejecting glitches and only passing state transitions after a required period of stability. Trigger after stable mode is used with electro-mechanical devices like encoders and mechanical switches to reject switch bounce and disturbances due to a vibrating encoder that is not otherwise moving. The debounce time should be set short enough to accept the desired input pulse but longer than the period of the undesired disturbance as shown in the diagram below.



Terms Applicable to Counter Modes

The following terms and definitions are provided as an aid to understanding counter modes.

Gating: Any counter can be gated by the mapped channel. When the mapped channel is high, the counter will be allowed to count, when the mapped channel is low, the counter will not count but hold its value.

Mapped Channel: A mapped channel is one of 4 signals that can get multiplexed into a channel's counter module. The mapped channel can participate with the channel's input signal by gating the counter, clearing the counter, etc. The 4 possible choices for the mapped channel are the 4 input signals (post debounce).

Start of Scan: The start of scan is a signal that is internal to the 3000USB Series board. It signals the start of a scan group and therefore pulses once every scan period. It can be used to clear the counters and latch the counter value into the acquisition stream.

Terminal Count: This signal is generated by the counter value. There are only two possible values for the terminal count: 65,535 for a 16-bit counter (Counter Low); and 4,294,967,295 for a 32-bit counter (Counter High). The terminal count can be used to stop the counter from rolling over to zero.

Ticksize: The ticksize is a fundamental unit of time and has four possible settings: 20.83ns, 208.3ns, 2083ns, 20833ns. For measurements that require a timebase reference like period or pulsewidth, the ticksize is the basic unit of time. Ticksize is derived from the period of the 48 MHz system clock. The count value returned in the scan is the number of ticks that make up the time measurement.

Counter Options

The following mode options are available with the /3000USB Series board and are detailed in the upcoming pages.
A separate block diagram has been created for each mode. Note that the **OPT** numbers relate to sections of the block diagrams.

Counter/Totalize Mode (see page 6):

OPT0: Selects *totalize* or *clear on read* mode.
OPT1: Determines if the counter is to *rollover* or "*stop at the top.*"
OPT2: Determines whether the counter is 16-bits (Counter Low); or 32-bits (Counter High).
OPT3: Determines which signal latches the counter outputs into the data stream back to the /3000USB Series board. Start of scan or mapped channel.
OPT4: Allows the mapped channel to gate the counter.
OPT5: Allows the mapped channel to decrement the counter.
OPT6: Allows the mapped channel to increment the counter.

Period Mode (see page 8):

OPT[1:0]: Determines the number of periods to time, per measurement (1, 10, 100, 1000).
OPT2: Determines whether the period is to be measured with a 16-bit (Counter Low); or 32-bit (Counter High).
OPT4: Allows the mapped channel to gate the counter.
OPT6: Allows the mapped channel to be measured for periods.

Pulsewidth Mode (see page 11):

OPT2: Determines whether the pulsewidth is to be measured with a 16-bit counter (Counter Low); or a 32-bit counter (Counter High).
OPT4: Allows the mapped channel to gate the counter.
OPT6: Allows the mapped channel to be measured for pulsewidth.

Timing Mode (see page 13).

OPT2: Determines whether the time is to be measured with a 16-bit counter (Counter Low); or a 32-bit counter (Counter High).

Encoder Mode (see page 15).

OPT[1:0]: Determines the encoder measurement mode: 1X, 2X, or 4X.
OPT2: Determines whether the counter is 16-bits (Counter Low); or 32-bits (Counter High).
OPT3: Determines which signal latches the counter outputs into the data stream going back to the /3000USB Series board. Start of scan or mapped channel.
OPT4: Allows the mapped channel to gate the counter.
OPT5: Allows the mapped channel to clear the counter for Z reference.

Counter/Totalize Mode

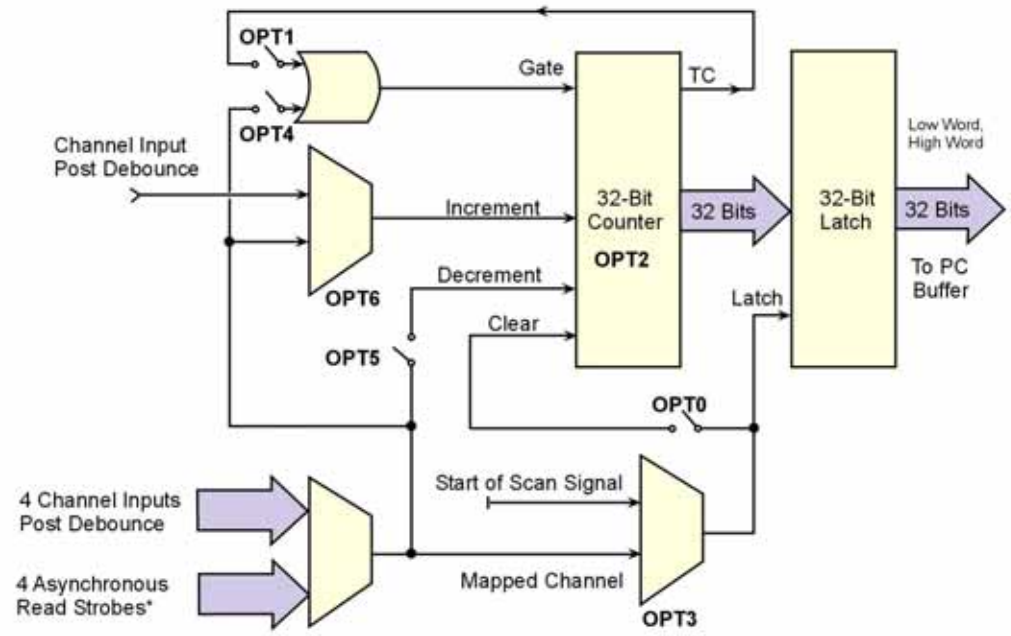
TIP: When using a counter for a trigger source, it is a good idea to use a pre-trigger with a value of at least 1. The reason is that all counters start at zero with the initial scan; and there will be no valid reference in regard to rising or falling edge. Setting a pre-trigger to 1 or more ensures that a valid reference value is present, and that the first trigger will be legitimate.

The *counter mode* allows basic use of a 32-bit counter. While in this mode, the channel's input can only increment the counter upward. When used as a 16-bit counter (Counter Low), one channel can be scanned at the 12 MHz rate. When used as a 32-bit counter (Counter High), two sample times are used to return the full 32-bit result. Therefore a 32-bit counter can only be sampled at a 6 MHz maximum rate. If only the upper 16 bits of a 32-bit counter are desired then that upper word can be acquired at the 12 MHz rate.

The first scan of an acquisition always zeroes all counters. It is usual for all counter outputs to be latched at the beginning of each scan; however, there is an option to change this. A second channel, referred to as the **"mapped" channel**, can be used to latch the counter output. The mapped channel can also be used to:

- **gate the counter**
- **increment the counter**
- **decrement the counter**

The mapped channel can be any of the 4 counter input channels (post-debounce), or any of the four asynchronous read strobes. When a counter is not in the scan it can be asynchronously read with, or without, *clear on read*. The asynchronous read-signals strobe when the lower 16-bits of the counter are read by software. The software can read the counter's high 16-bits at a later time, after reading the lower 16-bits. The full 32-bit result reflects the timing of the first asynchronous read strobe.



Counter/Totalize Mode

*There is one asynchronous read strobe for each of the four counter channels.

An explanation of the various counter options, depicted in the previous figure, follows.

COUNTER: OPT0: This selects *totalize* or *clear on read* mode.
Totalize Mode – The counter counts up and rolls over on the 16-bit (Low Counter) boundary, or on the 32-bit (High Counter) boundary. See OPT2 in regard to choosing 16-bit or 32-bit counters.
Clear On Read Mode – The counter is cleared at the beginning of every scan or synchronous read; and the final value of the counter [the value just before it was cleared] is latched and returned to the /3000USB Series board.

COUNTER: OPT1: This determines if the counter is to *rollover* or "*stop at the top*."
Rollover Mode - The counter continues to count upward, rolling over on the 16-bit (Counter Low) boundary, or on the 32-bit (Counter High) boundary. See OPT2 in regard to choosing 16-bit or 32-bit counters.
Stop at the Top Mode - The counter will stop at the top of its count. The top of the count is FFFF for the 16-bit option (Counter Low), and FFFFFFFF for the 32-bit option (Counter High).

COUNTER: OPT2: Determines whether the counter is **16-bits** or **32-bits** (Counter Low, or Counter High, respectively). This only matters when the counter is using the "stop at the top" option, otherwise this option is inconsequential.

COUNTER: OPT3: Determines which signal latches the counter outputs into the data stream back to the /3000USB Series board. Normally, the start of scan signal latches the counter outputs at the beginning of every scan; but an option is to have the mapped signal latch the counter outputs. This mapped-signal option allows a second signal to control the latching of the count data. This allows the user to know the exact counter value when an edge is present on another channel. This also allows the counters to be asynchronously read.

COUNTER: OPT4: Allows the **mapped channel to gate the counter** if desired. When the mapped channel is **high**, the counter is enabled. When the mapped channel is **low**, the counter is disabled (but holds the count value). The mapped channel can be any other input channel.

COUNTER: OPT5: Allows the **mapped channel to decrement the counter**. With this option the input channel [for the counter] will increment the counter. The mapped channel can be used to decrement the counter.

COUNTER: OPT6: Allows the **mapped channel to increment the counter** instead of the main channel. This option allows the counter to be used with any other input channel (post-debounce). If the channel's input is used elsewhere, for example, gating another counter, the counter for this channel does not need to go unused.

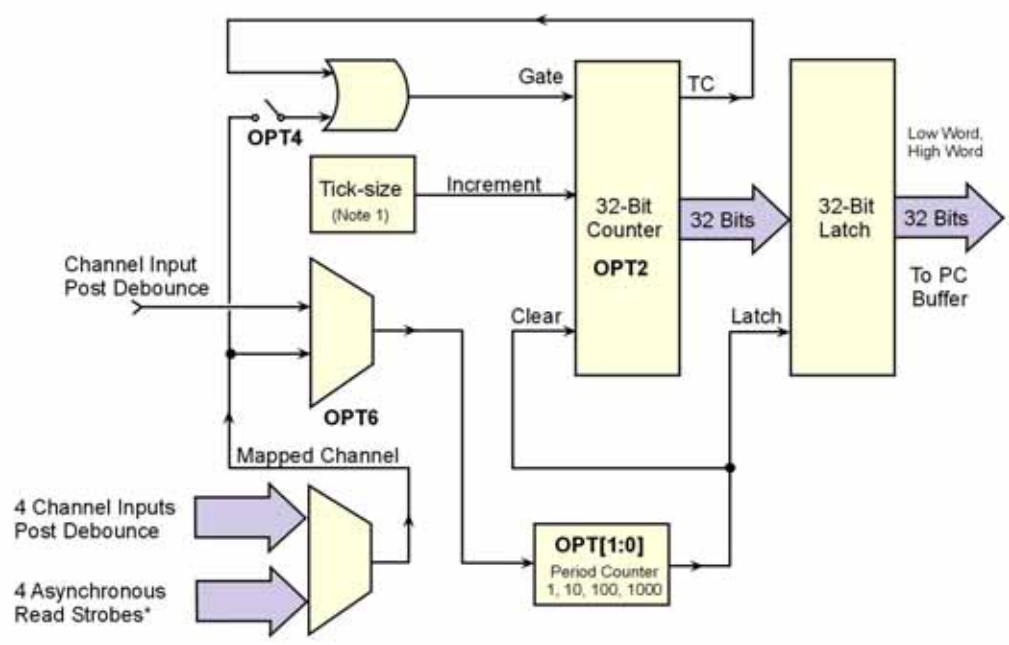
Asynchronously Reading These Counters

If the counter is in asynchronous mode the *clear on read* mode is available. The counter's lower 16-bit value should be read first. This will latch the full 32-bit result and clear the counter. The upper 16-bit value can be read after the lower 16-bit value. Also, counters can only be asynchronously read in modes that allow the mapped channel to latch the data, i.e., Counter and Encoder modes. However, it is possible for the user to use that read strobe as a mapped channel elsewhere, if desired. For example, the read strobe could be used to increment or decrement the counter.

Period Mode

TIP: When using a counter for a trigger source, it is a good idea to use a pre-trigger with a value of at least 1. The reason is that all counters start at zero with the initial scan; and there will be no valid reference in regard to rising or falling edge. Setting a pre-trigger to 1 or more ensures that a valid reference value is present, and that the first trigger will be legitimate.

This mode allows for period measurement of the channel input. The measurement period is the time from edge-to-edge, either both rising or both falling. Period data is latched as it becomes available and the data is logged by the /3000USB Series board at the scan rate. Therefore, if the scan period is much faster than the input waveform, there will be a great deal of repetition in the period values. This repetition is due to the fact that updates take place only when another full period becomes available.



Period Mode

*There is one asynchronous read strobe for each of the four counter channels.

Note 1: Tick-sizes are: 20.83ns, 208.3ns, 2083ns, and 20833ns, derived from the 48 MHz system clock.

An example: One channel's acquired data might be: 0,0,0,0,80,80,80,80,79,79,79,79,81,81,81,81,….. This data represents the number of ticksize intervals counted during the period measurement. The first value(s) returned will be zero since the counters are cleared at the beginning of the acquisition. The data comes in sets of four since the scan period is about one-fourth as long as the input channel's period. Every time the period measurement is latched from the counter, the counter is immediately cleared and begins to count the time for the subsequent period.

If the scan period is a lot slower than the input period, the acquired data will be missing some periods. To obtain greater resolution, you can increase the scan period, or use an averaging option (see OPT[1:0]).

The data returned is interpreted as time measured in ticks. There are four timebase settings: 20.83 ns, 208.3 ns, 2083 ns, and 20833 ns. These are often referred to as tick-sizes. The /3000USB Series board uses a 48 MHz, 50 ppm oscillator as a timing source. The tick sizes are derived from 1 period, 10 periods, 100 periods, or 1000 periods of the 48 MHz clock.

PERIOD: OPT[1:0]: Determines the **number of periods to time, per measurement**. This makes it possible to *average out jitter* in the input waveform, sampling error, noise, etc. There are four options:

(1) The channel's measurement is latched every time one complete period has been observed.

(2) The channel's measurement is latched every time that 10 complete periods have been observed. The value that gets returned is equal to 10 consecutive periods of the input channel.

(3) The number returned is 100 consecutive periods.

(4) The number returned is 1000 consecutive periods.

PERIOD: OPT2: Determines whether the period is to be measured with a **16-bit** (Counter Low), or **32-bit** (Counter High) counter. Since period measurements always have the "stop at the top" option enabled, this option dictates whether the measurement has a range of 0 to 65535 ticks or 0 to 4,294,967,295 ticks.

PERIOD: OPT4: Allows the **mapped channel to gate the counter** if desired. When the mapped channel is **high**, the counter is enabled. When the mapped channel is **low**, the counter is disabled, but still holds the count value. The mapped channel can be any other input channel.

PERIOD: OPT6: This allows a mapped channel's period to be measured, instead of the input channel. The mapped channel can be any other input channel (post debounce). This option allows the counter to be used with any other input channel (post-debounce). If the channel's input is used elsewhere, for example, gating another counter, the counter for this channel does not need to go unused.

Period and Frequency Accuracy

The /3000USB Series board can measure the period of any input waveform. It does this by counting the integral number of "ticks" that make up the period, the data returned will always be time measured in "ticks." The error in each data sample will come from two sources: the sampling error caused by not being able to count a partial "tick"; and the 3000USB Series Board's internal timebase inaccuracy. The board's internal timebase has an absolute accuracy of 50 ppm. The sampling error will vary with input frequency, selected ticksize, and selected averaging mode. The absolute error is the "root-sum-of-squares" of the two independent error sources.

Many times the desired accuracy is much less than what the internal timebase is capable of. Other applications will require a more accurate period measurement and the effects of sampling error will have to be averaged out leaving only the inaccuracy associated with the internal timebase. Inaccuracy due to the internal timebase cannot be averaged out.

For period and frequency measurements, percent sampling error is equal to 100%/(n+1) where n=0 to 65,535 for a 16-bit counter and n=0 to 4,294,967,295 for a 32-bit counter. For small count values, the sampling error is large and for large count values, the sampling error is small. If sampling error is to be less than 0.21%, n must be greater than 480 regardless of counter size.

Sampling error can also be reduced by averaging many samples together. Assuming the input signal is asynchronous to the board's internal timebase, sampling error can be divided by the square-root of the number of samples taken. The averaging can be done with PC-based software.

The board has the ability to measure 1, 10, 100 or 1000 periods, dividing the sampling error by 1, 10, 100, or 1000. This is done within the board circuitry and may eliminate the need for any averaging to be done in the PC. For high accuracy on high frequency inputs, multiple period measurement and PC-based averaging can be done.

The 3000USB Series board has the ability to provide various frequency ranges that are based upon different ticksizes, averaging options, and counter size (16 bit or 32 bit values.) The frequency ranges are designed to fit a wide array of possible applications. Within each range, the sampling error decreases dramatically as the input period increases. The ranges will get smaller as required accuracy increases.

Upper 16-bits of the 32-bit counter		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 1500u	20833.333	1
150u – 15m	2083.333	1
1500u – 150m	208.333	1
15m – 1500m	20.833	1
150m – 15	20.833	10
1500m – 150	20.833	100
15 – 1500	20.833	1000

Lower 16-bits of the 32-bit counter		
Range (Hz)	Ticksize (nS)	Averaging Option
1 – 100	20833.333	1
10 – 1k	2083.333	1
100 – 10k	208.333	1
1k – 100k	20.833	1
10k – 1M	20.833	10
100k – 5M	20.833	100
1M – 5M	20.833	1000

Frequency Ranges for a 16-bit value, sampling error is less than 0.21%

Each frequency range given in the previous table-set can be exceded. If the input waveform goes under-range by too much, the counter value will top out at 65535 indicating you have reached the lowest possible frequency that can be measured on that range. If the input waveform goes over range by too much, the counter will return values that are very course and have a lot of sampling error. The values returned will have a small number of counts for the period duration. If an input waveform cannot fit within one of the 16-bit ranges shown above or requires much higher accuracy, then a 32-bit range should be considered.

Full 32-bit Counter		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 100	20833.333	1
150u – 1k	2083.333	1
1.5m – 10k	208.333	1
15m – 100k	20.833	1
150m – 1M	20.833	10
1.5 – 5M	20.833	100
15 – 5M	20.833	1000

Frequency Ranges for a 32-bit Value,
Sampling Error is Less than 0.21%

The 32-bit ranges shown above are much wider than the 16-bit ranges, but also require the full 32-bit value to be returned. Since digital or counter channels do not take up any time in the scan period there is no disadvantage in reading a 32-bit counter versus a 16-bit counter. The 32-bit frequency ranges can also be exceeded with a loss of accuracy or topping out at 4,294,967,295 counts.

Some measurements will require the accuracy of an input waveform to be free of sampling error, having only the absolute accuracy of the internal timebase as the source of error. Sampling error can be averaged out to give the required result. In most cases, the 3000USB Series board can perform the required averaging on the values before they are returned to the PC. The frequency ranges shown below will give a sampling error that is less than 10ppm or 1ppm.

Full 32-bit Counter **<10 ppm**		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 500m	20833.333	1
150u – 5	2083.333	1
1.5m – 50	208.333	1
15m – 500	20.833	1
150m – 5k	20.833	10
1.5 – 50k	20.833	100
15 – 500k	20.833	1000

Full 32-bit Counter **<1 ppm**		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 50m	20833.333	1
150u – 500m	2083.333	1
1.5m – 5	208.333	1
15m – 50	20.833	1
150m – 500	20.833	10
1.5 – 5k	20.833	100
15 – 50k	20.833	1000

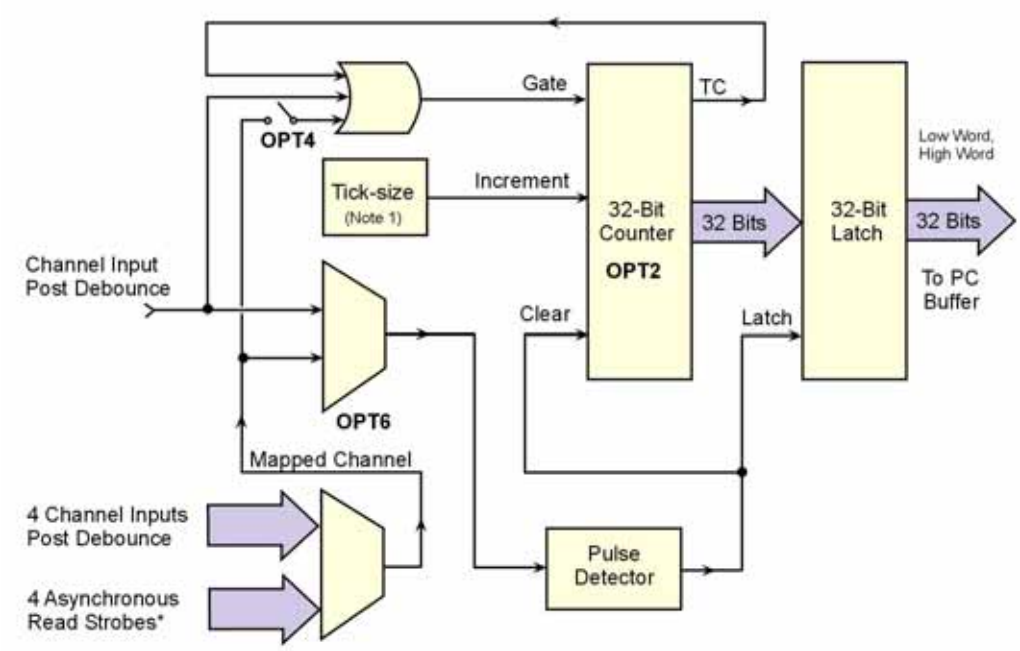
High Accuracy Frequency Ranges for a 32-bit Value
that has little sampling error (<10ppm, <1ppm)

If the input frequency is required to have less than 1 ppm sampling error and is greater than 50kHz, use the 15– 50kHz, 1ppm range. The values returned will have sampling error that is greater than 1ppm but they can be averaged by the PC software to further reduce the sampling error.

Pulsewidth Mode

TIP: When using a counter for a trigger source, it is a good idea to use a pre-trigger with a value of at least 1. The reason is that all counters start at zero with the initial scan; and there will be no valid reference in regard to rising or falling edge. Setting a pre-trigger to 1 or more ensures that a valid reference value is present, and that the first trigger will be legitimate.

This mode provides a means to measure a channel's pulsewidth. The measurement is the time from the rising edge to the falling edge, or visa versa. The measurement will be either pulsewidth low, or pulsewidth high, depending upon the edge polarity set in the debounce module.
Every time the pulsewidth measurement is latched from the counter, the counter is immediately cleared and enabled to count the time for the next pulsewidth. The pulsewidth measurements are latched as they become available.



Pulsewidth Mode

*There is one asynchronous read strobe for each of the four counter channels.
Note 1: Tick-sizes are: 20.83ns, 208.3ns, 2083ns, and 20833ns, derived from the 48 MHz system clock.

An example: one channel's acquired data might be: 0,0,0,0,80,80,80,80,79,79,79,79,81,81,81,81,….
This data represents the number of ticksize intervals counted during the pulsewidth measurement. The first value(s) returned will be zero since the counters are cleared at the beginning of the acquisition. In this example the data comes in sets of four because the scan period is about one-fourth as long as the input channel's period. Every time the pulsewidth measurement is latched from the counter, the counter is immediately cleared and enabled to count time for the next pulsewidth.

If the scan period is much slower than the input period, then the acquisitions will miss some pulsewidths. Decreasing the scan period will increase the number of different pulsewidths received.

The data returned is interpreted as time measured in ticks. There are four timebase settings: 20.833 ns, 208.33 ns, 2.083 µs, and 20.83 µs. These are often referred to as tick-sizes. The 3000USB Series board uses a 48 MHz, 50 ppm oscillator as a timing source.

If the input signal has a poor slew rate the pulsewidth mode will provide variant results.

PULSEWIDTH: OPT2: Determines whether the pulsewidth is to be measured with a **16-bit** (Counter Low), or **32-bit** (counter High) counter. Since pulsewidth measurements always have the "stop at the top" option enabled, this option dictates whether the measurement has a range of 0 to 65535 ticks, or 0 to 4,294,967,295 ticks.

PULSEWIDTH: OPT4: Allows the **mapped channel to gate the counter**. When the mapped channel is **high**, the counter is enabled to count. When the mapped channel is **low**, the counter is disabled, but holds the count value. The mapped channel can be any other input channel.

PULSEWIDTH: OPT6: This allows the mapped channel's pulsewidth to be measured instead of the input channel. The mapped channel can be any other input channel (post debounce). This option allows the counter to be used with any other input channel (post-debounce). If the channel's input is used elsewhere, for example, gating another counter, the counter for this channel does not need to go unused.

Pulsewidth and Timing mode Accuracy

The 3000USB Series board has the ability to measure the pulsewidth of an input and the time between any two edges on any two inputs. The time ranges are similar to those shown for period mode except that averaging is not available. The ranges given below reflect this.

Upper 16-bits of the 32-bit Counter		
Range (S)	Ticksize (nS)	Averaging Option
800 – 80000	20833.333	1
80 – 8000	2083.333	1
8 – 800	208.333	1
800m – 80	20.833	1

Lower 16-bits of the 32-bit Counter		
Range (S)	Ticksize (nS)	Averaging Option
10m – 1	20833.333	1
1m – 100m	2083.333	1
100u – 10m	208.333	1
10u – 1m	20.833	1

Pulsewidth and Time Ranges for a 16-bit Value
Sampling error is less than 0.21%

Full 32-bit Counter		
Range (S)	Ticksize (nS)	Averaging Option
10m – 80000	20833.333	1
1m – 8000	2083.333	1
100u – 800	208.333	1
10u - 80	20.833	1

Pulsewidth and Time Ranges for a 32-bit Value
Sampling error is less than 0.21%

Full 32-bit Counter <10 ppm		
Range (S)	Ticksize (nS)	Averaging Option
2 – 80000	20833.333	1
200m – 8000	2083.333	1
20m – 800	208.333	1
2m – 80	20.833	1

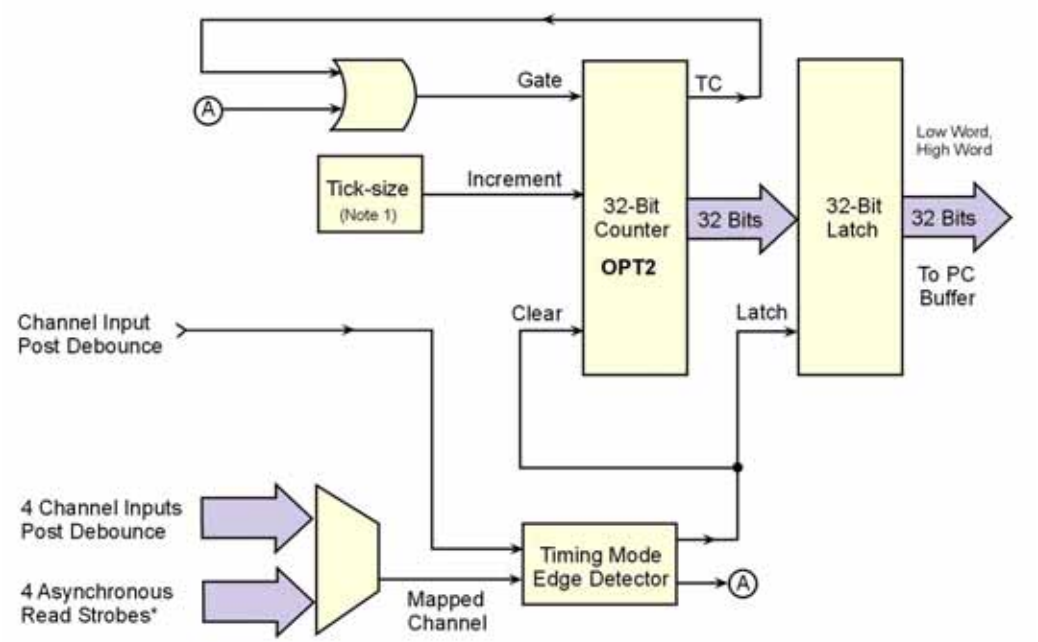
Full 32-bit Counter <1 ppm		
Range (S)	Ticksize (nS)	Averaging Option
20 – 80000	20833.333	1
2 – 8000	2083.333	1
200m – 800	208.333	1
20m – 80	20.833	1

High Accuracy Pulsewidth and Time Ranges for a 32-bit Value
that has little sampling error (<10ppm, <1ppm)

Timing Mode

TIP: When using a counter for a trigger source, it is a good idea to use a pre-trigger with a value of at least 1. The reason is that all counters start at zero with the initial scan; and there will be no valid reference in regard to rising or falling edge. Setting a pre-trigger to 1 or more ensures that a valid reference value is present, and that the first trigger will be legitimate.

This mode provides a means of measuring time between two subsequent events, i.e., the edge of one channel with respect to the edge of another channel. The edge selection is done in each channel's debounce setup. Whenever the time measurement is latched from the counter, the counter is immediately cleared and enabled for accepting the subsequent time period, which starts with the next edge on the main channel.



Timing Mode

*There is one asynchronous read strobe for each of the four counter channels.

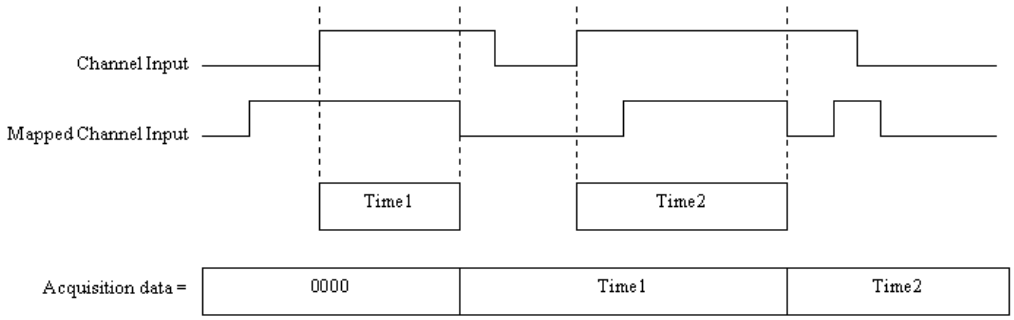
Note 1: Tick-sizes are: 20.83ns, 208.3ns, 2083ns, and 20833ns, derived from the 48 MHz system clock.

An Example of Timing Mode

The following example represents one channel in timing mode. The time desired is between the *rising edge* on the **input channel** and the *falling edge* on the **mapped channel**. Zeroes are returned, in the scan, until one complete time measurement has been taken. At that point, the value (time in ticks) is latched and logged by the /3000USB Series board until the next time measurement has been completed. Rising edges on the input channel will clear the counter and falling edges on the mapped channel will latch the output of the counter at that time. If the scan period is much slower than the rate of time-frames coming [available on the two channels] then the data will miss some time-frames. The scan period can be decreased to capture more time-frames.

The data returned is interpreted as time measured in ticks. This data represents the number of ticksize intervals counted during the timing measurement. There are four timebase settings: 20.833 ns, 208.33 ns, 2.083 µs, and 20.83 µs. These are often referred to as tick-sizes. The 3000USB Series board uses a 48 MHz, 50 ppm oscillator as a timing source.

If the input signal has a poor slew rate the timing mode will provide variant results, dependant upon the input switching threshold.



Example of One Channel in Timing Mode

TIMING: OPT2: This determines whether the time is to be measured with a **16-bit** (Counter Low), or **32-bit** (Counter High) counter. Since time measurements always have the "stop at the top" option enabled, this option dictates whether the measurement has a range of 0 to 65535 ticks or 0 to 4,294,967,295 ticks.

Encoder Mode

TIP: When using a counter for a trigger source, it is a good idea to use a pre-trigger with a value of at least 1. The reason is that all counters start at zero with the initial scan; and there will be no valid reference in regard to rising or falling edge. Setting a pre-trigger to 1 or more ensures that a valid reference value is present, and that the first trigger will be legitimate.

Introduction

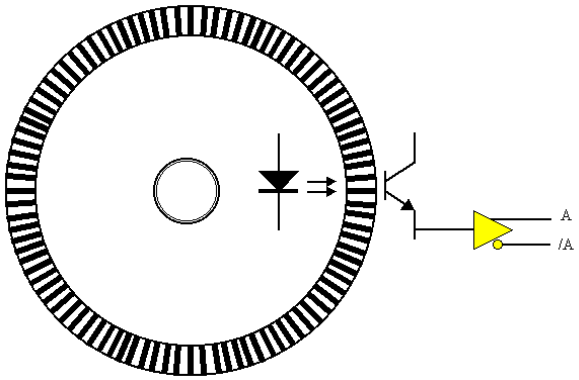
Rotary shaft encoders are frequently used with CNC equipment, metal-working machines, packaging equipment, elevators, valve control systems, and in a multitude of other applications in which rotary shafts are involved.

The *encoder mode* allows the 3000USB Series board to make use of data from optical incremental quadrature encoders. When in the *encoder mode*, the board accepts *single-ended* inputs. When reading phase A, phase B, and index Z signals, the 3000USB Series board provides positioning, direction, and velocity data.

The 3000USB Series board can only receive input from up to two encoders.

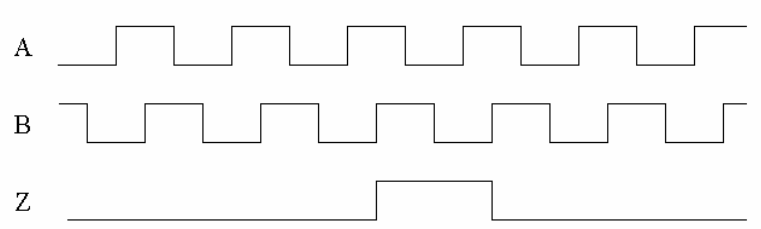
The 3000USB Series board supports quadrature encoders with a 16-bit (Counter Low), or a 32-bit (Counter High) counter, 20 MHz frequency, and x1, x2, and x4 count modes. With only phase A and phase B signals, 2 channels are supported; with phase A, phase B, and index Z signals, 1 channel is supported.

Quadrature encoders generally have 3 outputs: A, B, and Z. The A and B signals are pulse trains driven by an optical sensor inside the encoder. As the encoder shaft rotates, a laminated optical shield rotates inside the encoder. The shield has three concentric circular patterns of alternating opaque and transparent windows through which an LED will shine. There is one LED for each of the concentric circular patterns and likewise, one phototransistor. One phototransistor produces the A signal, another phototransistor produces the B signal and the last phototransistor produces the Z signal. The concentric pattern for A has 512 window pairs (or 1024, 4096, etc.)



The concentric pattern for B has the same number of window pairs as A except that the entire pattern is rotated by 1/4 of a window-pair. Thus the B signal will always be 90 degrees out of phase from the A signal. The A and B signals will pulse 512 times (or 1024, 4096, etc.) per complete rotation of the encoder.

The concentric pattern for the Z signal has only one transparent window and therefore pulses only once per complete rotation. Representative signals are shown in the following figure.

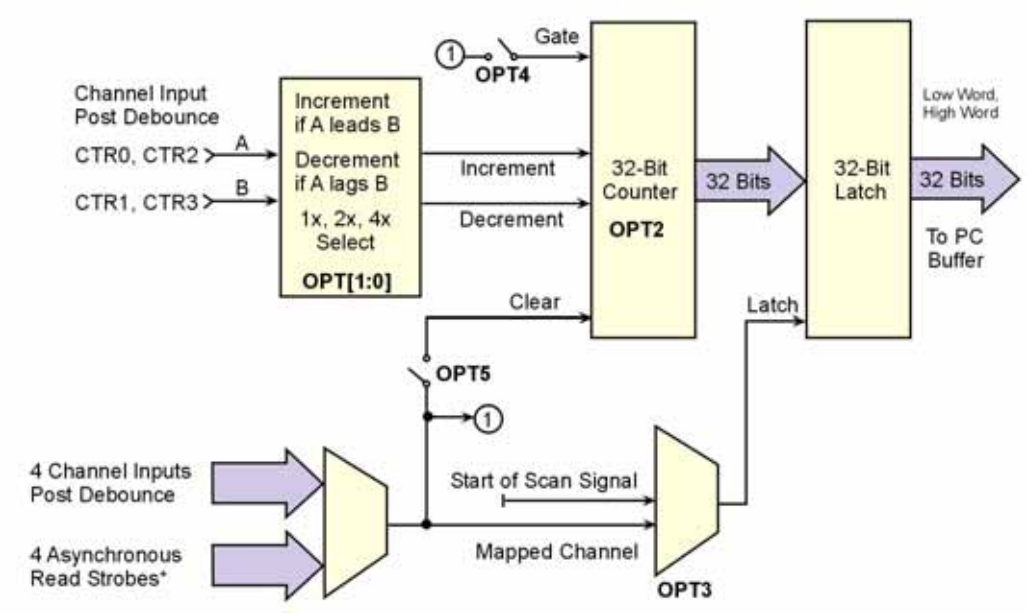


Representation of Quadrature Encoder Outputs: A, B, and Z

As the encoder rotates, the A (or B) signal is indicative of the distance the encoder has traveled. The frequency of A (or B) indicates the velocity of rotation of the encoder. If the Z signal is used to zero a counter (that is clocked by A) then that counter will give the number of pulses the encoder has rotated from its reference. The Z signal is a reference marker for the encoder. It should be noted that when the encoder is rotating clockwise (as viewed from the back), A will lead B and when the encoder is rotating counter-clockwise, A will lag B. If the counter direction control logic is such that the counter counts upward when A leads B and counts downward when A lags B, then the counter will give direction control as well as distance from the reference.

An Example of Encoder Accuracy

If there are 512 pulses on A, then the encoder position is accurate to within 360 degrees/512. Even greater accuracy can be obtained by counting not only rising edges on A but also falling edges on A, giving position accuracy to 360 degrees/1024. The ultimate accuracy is obtained by counting rising and falling edges on A and on B (since B also has 512 pulses.) This gives a position accuracy of 360 degrees/2048. These 3 different modes are known as 1X, 2X, and 4X. The 3000USB Series board implements all of these modes and functions, as described in the following options.



Encoder Mode

*There is one asynchronous read strobe for each of the four counter channels.

ENCODER: OPT[1:0]: This determines the encoder measurement mode: 1X, 2X, or 4X.

ENCODER: OPT3: This determines which signal latches the counter outputs into the data stream going back to the /3000USB Series board. Normally, the start of scan signal latches the counter outputs at the beginning of every scan. The other option is to have the mapped signal latch the counter outputs. This allows the user to have another signal control the latching of the count data, so the exact value of the counter is known when an edge is present on another channel.

ENCODER: OPT4: This allows the mapped channel to gate the counter if desired. When the mapped channel is high, the counter is enabled to count, when the mapped channel is low, the counter is disabled (but holds the count value.) The mapped channel can be any other input channel.

ENCODER: OPT5: This allows the mapped channel to clear the counter if desired. OPT5 implements the Z-function [described above], allowing the encoder reference to clear the counter. The counter is cleared on the rising edge of the mapped channel.

Encoder Wiring Diagrams

You can use up to two encoders with each 3000USB Series board module in your acquisition system. Each A and B signal can be made as a single-ended connection with respect to common ground.

Encoder wiring diagrams and example setup tables are included in the following pages; refer to them as needed.

For Single-ended Connections:

For single-ended applications, the connections made from the encoder to the 3000USB Series board are as follows:

- Signals A, B, and Z connect to the Counter Inputs on 3000USB Series board.
- Each encoder ground connects to GND.
- +5 V is available on the 68-pin SCSI connector for powering encoders.

Differential applications are not supported.

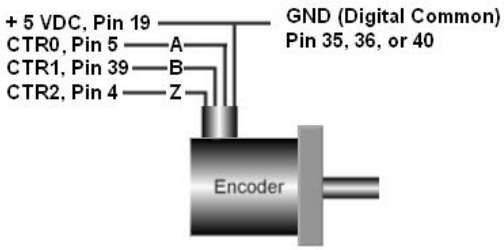
For Open-Collector Outputs: External ***pullup resistors*** can be connected to the 3000USB Series board's counter input terminal blocks. A pullup resistor can be placed between any input channel and the encoder power supply.

Choose a pullup resistor value based on the encoder's output drive capability and the input impedance of the 3000USB Series board. Lower values of pullup resistors will cause less distortion but also cause the encoder's output driver to pull down with more current.

Wiring for 1 Encoder

The following figure illustrates connections for one encoder to a 68-pin SCSI connector on a DaqBoard/3000USB Series board.

The "A" signal must be connected to an even-numbered channel and the associated "B" signal must be connected to the next [higher] odd-numbered channel. For example, if "A" were connected to CTR0, "B" would be connected to CTR1.



Encoder Connections to pins on the SCSI Connector*

* Connections can instead, be made to the associated screw-terminals of a connected TB-100 terminal connector option.

In addition to the previous figure, the following table indicates how to connect a single encoder to a 3000USB Series board. Each signal (A, B, Z) can be connected as a single-ended connection with respect to the common ground. The encoder can draw power from the 3000USB Series board's +5 VDC power output (pin 19). Connect the encoder's power input to the +5V pin and connect the return to digital common (GND) on the same connector.

The programming setup given below is just a representative of possible options.

Single Encoder – Programming Example Setup		
SCSI Pin	**Connects to:**	**Example Programming Setup**
Pin 5 (CTR0)	Encoder – A	Encoder Mode, 4X option, 16-bit counter, Latch on SOS, Map channel Clears the counter, set Map channel to CTR2.
Pin 39 (CTR 1)	Encoder – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksize to 208.3 ns.
Pin 4 (CTR2)	Encoder – Z	Counter in Totalize mode, stop-at-the-top, 16-bit counter.

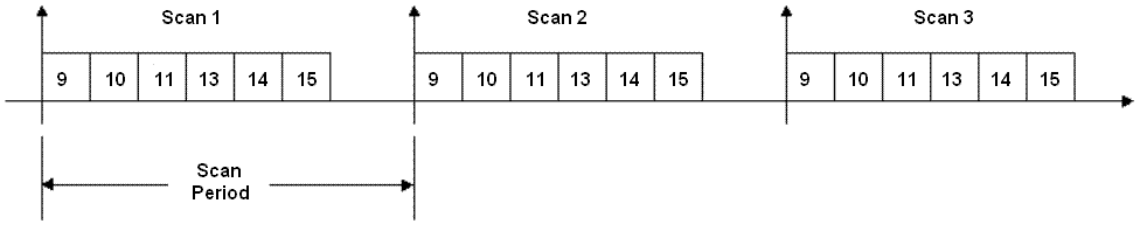
If the encoder stops rotating, but is vibrating [due to the machine it is mounted to], the debounce feature can be used to eliminate false edges. An appropriate debounce time can be chosen and applied to each encoder channel. Refer to the *Debounce Module* section on page 1 for additional information regarding debounce times.

Relative position and *velocity* can be obtained from the encoder. However, during an acquisition, data that is relative to the Z-position cannot be obtained until the encoder locates the Z-reference.

During an acquisition, data that is relative to the Z-position cannot be obtained until the encoder locates the Z-reference.

Note that the number of Z-reference crossings can be tabulated. If the encoder was turning in only one direction, then the Z-reference crossings will equal the number of complete revolutions. This means that the data streaming to the PC will be *relative position*, *period = 1/velocity*, and *revolutions*.

A typical acquisition might take 6 readings off of the 3000USB Series board module as illustrated below. The user determines the scan rate and the number of scans to take.



DaqBoard/3000USB Series board Acquisition of Six Readings per Scan

Note: Digital channels do not take up analog channel scan time.

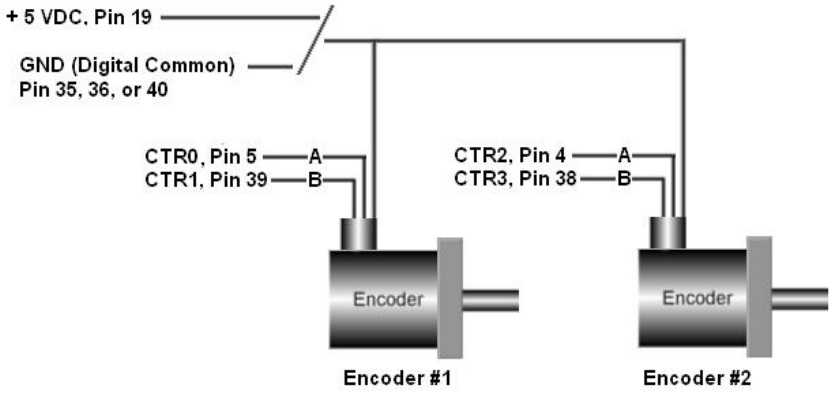
In general, the output of each channel's counter is latched at the beginning of each scan period (called the *start-of-scan*.) Every time the 3000USB Series board receives a *start-of-scan* signal, the counter values are latched and are available to the /3000USB Series board.

The 3000USB Series board clears all counter channels at the beginning of the acquisition. This means that the values returned during scan period 1 will always be zero. The values returned during scan period 2 reflect what happened during scan period 1.

The scan period defines the timing resolution for the /3000USB Series board. If you need a higher timing resolution, shorten the scan period.

Wiring for 2 Encoders

The following figure illustrates single-ended connections for two encoders. Differential connections are not applicable.



Two Encoders Connected to pins on the SCSI Connector*

* Connections can instead, be made to the associated screw-terminals of a connected TB-100 terminal connector option.

Connect two encoders to the 3000USB Series board as shown in the table below. Each signal (A, B) can be connected as a single-ended connection with respect to the common digital ground (GND). Both encoders can draw their power from the +5V power output (pin 19) on the 68-pin SCSI connector.

Connect each encoder's power input to +5V power. Connect the return to digital common (GND) on the same connector. Make sure that the current output spec is not violated. The programming setup given below is just a representative of possible options.

Two Encoders – Programming Example Setup		
SCSI Pin	**Connects to:**	**Example Programming Setup**
Pin 5 (CTR0)	Encoder #1 – A	Encoder Mode, 1X option, 16-bit counter, Latch on SOS
Pin 39 (CTR 1)	Encoder #1 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksize to 20833 ns
Pin 4 (CTR2)	Encoder #2 – A	Encoder Mode, 2X option, 16-bit counter, Latch on SOS
Pin 38 (CTR3)	Encoder #2 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksize to 2083.3 ns

With the encoders connected in this manner there is no relative positioning information available on encoder #1 or #2 since there is no Z signal connection for either. Therefore only distance traveled and velocity can be measured for each encoder.

Setpoint Configuration for Output Control 6

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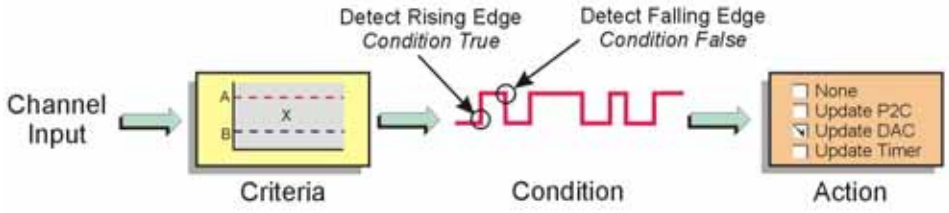
Overview

DaqBoard/3000 Series boards include a setpoint configuration feature which allows the user to individually configure up to 16 detection setpoints associated with channels within a scan group. Each detection setpoint can be programmed in the following ways:

- **Single Point referenced** – above, below, or equal to the defined setpoint
- **Window (dual point) referenced** – inside, or outside the window
- **Window (dual point) referenced, Hysterisis Mode** – outside the window high forces one output (designated "Output 2"; outside the window low forces another output, designated as "Output 1."



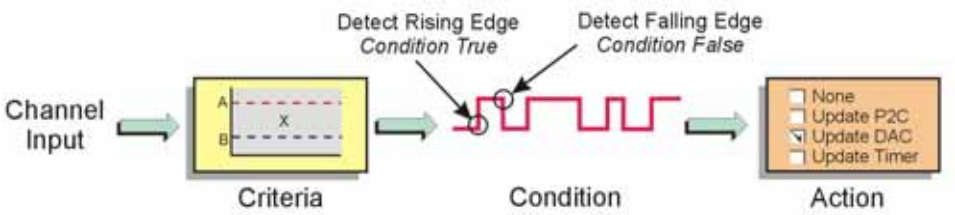
A digital detect signal is used to indicate when a signal condition is True or False, i.e., whether or not the signal has met the defined criteria. The detect signals themselves can be part of the scan group and can be measured as any other input channel; thus allowing real time data analysis during an acquisition.

Each setpoint can update the following, allowing for real time control based on acquisition data:

- **P2C digital output port with a data byte and mask byte**
- **analog outputs (DACs)**
- **timers**

The detection module looks at the 16-bit data being returned on a given channel and generates another signal for each channel with a setpoint applied: Detect1 for Channel 1, Detect2 for Channel 2, etc. These signals serve as data markers for each channel's data. It doesn't matter whether that data is volts, counts, period, pulsewidth, timing, or encoder position.

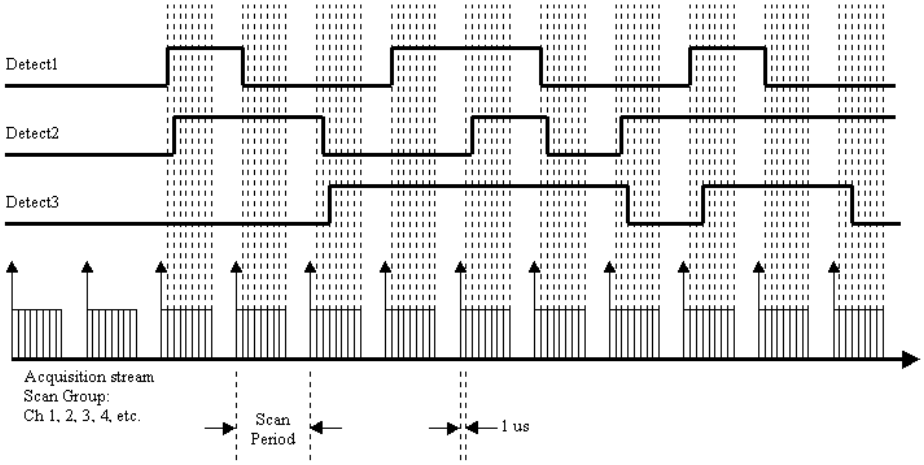
A channel's detect signal will show a **rising edge** and will be **True (1)** when the channel's data meets the setpoint criteria. The detect signal will show a **falling edge** and will be **False (0)** when the channel's data does not meet the setpoint criteria. The true and false states, for each setpoint criteria, appear in the *Setpoint Status Register* (see page 6-11).



Criteria Input Signal is Equal to X			Action Driven by Condition
Compare X To:	**Setpoint Definition:**		**Update Conditions:**
Limit A or Limit B	• Equal to A • Below A (Choose 1) • Above B	X = A X < A X > B	**True Only**: If True, then Output Value 1; If False, then perform no action **True and False**: If True, then Output Value 1; If False, then Output Value 2
Window* (non-Hysterisis Mode)	• Inside • Outside (Choose 1)	B < X < A B > X; or X > A	**True Only**: If True, then Output Value 1; If False, then perform no action **True and False**: If True, then Output Value 1; If False, then Output Value 2
Window* (Hysterisis Mode)	• Above A • Below B *(Both conditions are checked when in Hysterisis Mode)*	X > A X < B	**Hysterisis Mode (Forced Update)**: If X > A is True, then Output Value 2 until X < B is True, then Output Value 1. If X < B is True, then Output Value 1 until X > A is True, then Output Value 2. This is saying: (a) If the input signal is outside the window "high", then Output Value 2 until the signal goes outside the window "low" and (b) if the signal is outside the window low, then Output Value 1 until the signal goes outside the window "high." There is no change to the detect signal while within the window.

***** Value A defines the upper limit of the Window and Value B defines the low limit.

The detect signal has the timing resolution of the scan period as seen in the diagram below. The detect signal can change no faster than the scan frequency (1/scan period.)



Example Diagram of Detection Signals for Channels 1, 2, and 3

Each channel in the scan group can have one detection setpoint. There can be no more than 16 setpoints, in total, applied to channels within a scan group.

Detection setpoints act on 16-bit data only. Since the DaqBoard/3000 Series boards have 32-bit counters, data is returned 16-bits at a time. The lower word, the higher word or both lower and higher words can be part of the scan group. Each counter input channel can have 1 detection setpoint for the counter's lower 16-bit value and 1 detection setpoint for the counter's higher 16-bit value.

Detecting Input Values

All setpoints are programmed as part of the pre-acquisition setup, similar to setting up the analog path, debounce mode, or counter mode setup. Since each setpoint acts on 16-bit data, each has two 16-bit compare values: **Limit A** (High Limit) and **Limit B** (Low Limit). These limits define the setpoint window.

There are several possible conditions (criteria) and effectively 3 update modes, as can be seen in the following configuration summary.

Setpoint Configuration Summary

- ◊ **16-bit High Limit** Identified as "Limit A" in software
- ◊ **16-bit Low Limit** Identified as "Limit B" in software
- ◊ **Criteria:**

Inside window	Signal is below Limit A and Above Limit B
Outside window	Signal is above Limit A, or below Limit B
Greater than value	Signal is above Limit B, *Limit A is not used*
Less than value	Signal is below Limit A, *Limit B is not used*
Equal to value	Signal is equal to Limit A, *Limit B is not used.* Note that the *Equal to mode* is intended for use with counter or digital input channels [as the source channel]. See the TIP below.
Hysteresis mode	*Outside the window high* forces Output 2 until an *outside the window low* condition exists; then Output 1 is forced. Output 1 continues until an *outside the window high* condition exists. The cycle repeats as long as the acquisition is running in Hysterisis mode.

- ◊ **Update Mode:**
  Update on True Only
  Update on True and False
  None - Do not update
- ◊ **16-bit DAC value, P2C value, or Timer value when input meets criteria**
- ◊ **16-bit DAC value, P2C value, or Timer value when input does not meet criteria**
- ◊ **Type of Action:**
  None
  Update P2C (see note)
  Update DACx
  Update TImerx

By software default, P2C comes up as a digital input. If you want the P2C signal to be a digital output [in some initial state before an acquisition is started] and P2C is to be updated by set point criterion, then you must do an asynchronous write to P2C before the acquisition is started. The initial value will only be output if the asynchronous write to P2C has been performed.

When using setpoints with triggers *other than* immediate, hardware analog, or TLL, the setpoint criteria evaluation will begin immediately upon arming the acquisition.

TIP: It is recommended that the "Equal to Limit A" mode only be used with counter or digital input channels as the channel source. If similar functionality is desired for analog channels, then the "Inside Window" mode should be used.

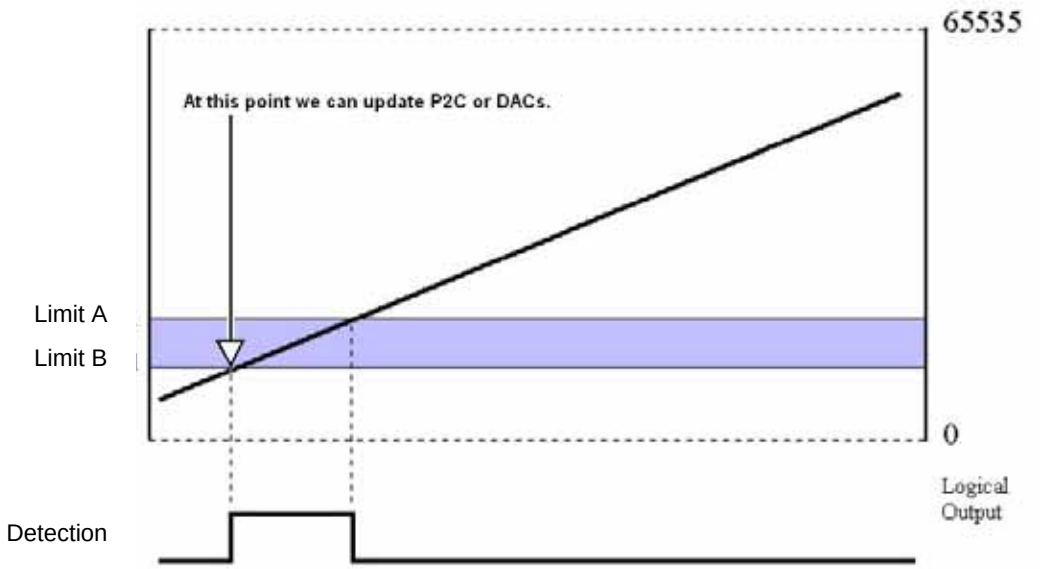
Each setpoint can be programmed with an 8-bit digital output byte and corresponding 8-bit mask byte. When the setpoint criteria has been met, the P2C digital output port can be updated with the given byte and mask. Alternately, each setpoint can be programmed with a 16-bit DAC update value, any one of the 4 DAC outputs can be updated in real time. Any setpoint can also be programmed with a timer update value.

In *hysteresis mode* each setpoint has two forced update values. Each update value can drive one DAC, one timer, or the P2C digital output port. *In hysteresis mode the outputs do not change when the input values are inside the window*. There is one update value that gets applied when the input values are less than the window and a different update value that gets applied when the input values are greater than the window.

Update on True and False uses two update values. There is one update value that gets applied when the specified criteria is met (True) and a different update value that gets applied when the specified criteria is not met (False). The update values can drive DACs, P2C, or timer outputs.

Example: Setpoint Detection on a Totalizing Counter

In the following figure Channel 1 is a counter in totalize mode. Two setpoints are used to define a point of change for Detect 1 as the counter counts upward. The detect output will be high when inside the window (greater than Limit B (the low limit) but less than Limit A (the high limit). In this case, the Channel 1 setpoint is defined for the 16 lower bits of channel 1's 32-bit value. The P2C digital output port could be updated on a True condition (the rising edge of the Detection signal). Alternately, one of the DAC output channels, or timer outputs, could be updated with a value.



Channel 1 in Totalizing Counter Mode, Inside the Window Setpoint

The detection circuit works on data that is put into the acquisition stream at the scan rate. This data is acquired according to the pre-acquisition setup (scan group, scan period, etc.) and returned to the PC. Counters are latched into the acquisition stream at the beginning of every scan. The actual counters may be counting much faster than the scan rate and therefore only every 10^{th}, 100^{th}, or n^{th} count will show up in the acquisition data. Therefore it is possible to set a small detection window on a totalizing counter channel and have the detection setpoint "stepped over" since the scan period was too long. Even though the counter value stepped into and out of the detection window, the actual values going back to the PC may not. This is true no matter what mode the counter channel is in.

The setting of a detection window must be done with a scan period in mind. This applies to analog inputs and counter inputs. Quickly changing analog input voltages can step over a setpoint window if not sampled often enough.

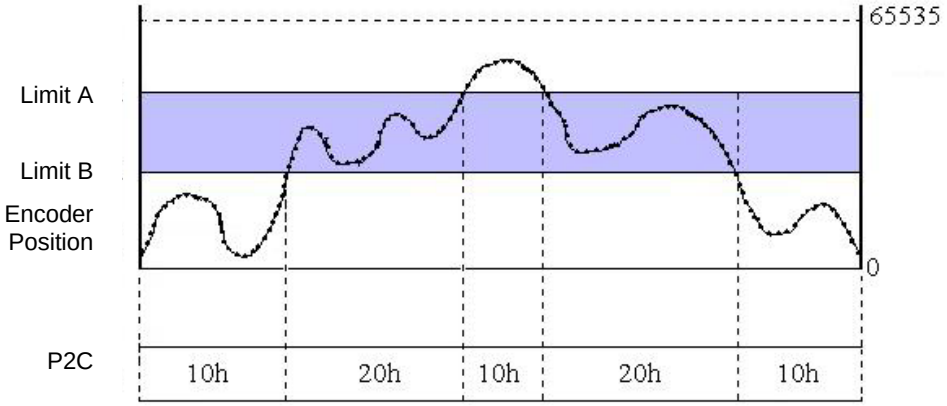
There are three possible solutions for overcoming this problem:

(1) The scan period could be shortened to give more timing resolution on the counter values or analog values

(2) The setpoint window can be widened by increasing Limit A and/or lowering Limit B.

(3) A combination of both solutions (1 and 2) could be made.

Example: Setpoint Detection on a Counter in Encoder Mode.



Example of a Counter in Encoder Mode

The figure above shows values pertaining to a Counter in Encoder Mode. The acquisition is started and 16-bit data [from the counter] streams into the PC at the scan rate. The 16-bit counter data is interpreted as the position from an encoder, which is connected to the counter inputs.

The update on *True and False* mode is being used. Thus, one value is output on P2C when the position is *outside of the window* (a value of 10h in the example); and a second value is output on P2C when the position is *inside the window* (a value of 20h in the example).

In the *True and False* mode, each setpoint has two DAC update values, two P2C update values, or 2 timer update values. One of the two values is used to update the DACs, P2C, or timers when it is *true* that the input channel meets the setpoint criteria. The second value is used to update the DACs, P2C, or timers when the condition is *false*, i.e., when the setpoint criteria is not met.

By software default, P2C comes up as a digital input. If you want the P2C signal to be a digital output [in some initial state before an acquisition is started] and P2C is to be updated by set point criterion, then you must do an asynchronous write to P2C before the acquisition is started. The initial value will only be output if the asynchronous write to P2C has been performed.

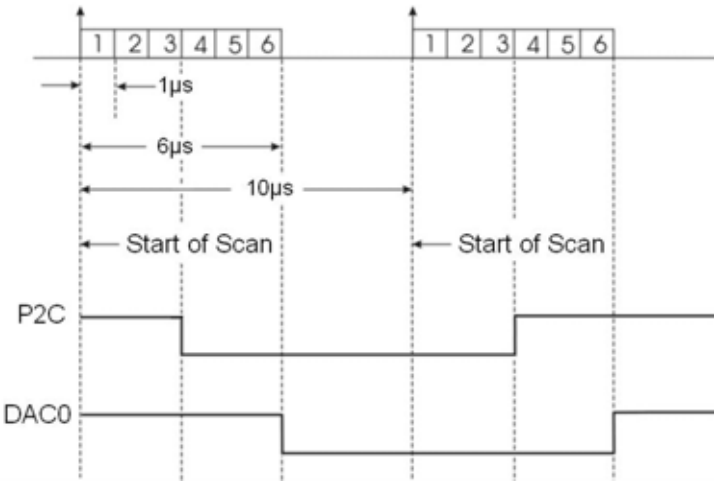
P2C, DAC, or Timer Update Latency

Setpoints allow DACs, timers, or P2C digital outputs to be updated very quickly. Exactly how fast an output can be updated is determined by the following three factors:

- **scan rate**
- **synchronous sampling mode**
- **type of output to be updated**

Example:

We set an acquisition to have a scan rate of 100 kHz. This means each scan period is 10µs. Within the scan period we will sample six analog input channels. These are shown in the following figure as Channels 1 through 6. The ADC conversion occurs at the beginning of each channel's 1µs time block.



Example of P2C or DAC Latency

If we apply a setpoint on analog input Channel 2, then that setpoint will get evaluated every 10µs with respect to the sampled data for Channel 2.

Due to the pipelined architecture of the Analog-to-Digital Converter system, the setpoint cannot be evaluated until 2µs after the ADC conversion. In the example above, the P2C digital output port can be updated no sooner than 2µs after Channel 2 has been sampled, or 3µs after the start of the scan. This 2µs delay is due to the pipelined ADC architecture. The setpoint is evaluated 2µs after the ADC conversion and then P2C can be updated immediately.

P2C digital outputs can be updated immediately upon setpoint detection. This is not the case for analog outputs, as these incur another 3µs delay. This is due to the shifting of the digital data out to the D/A converter which takes 1µs, plus the actual conversion time of the D/A converter, i.e., another 2µs (worst case). Going back to the above example, if the setpoint for analog input Channel 2 required a DAC update it would occur 5µs after the ADC conversion for Channel 2, or 6µs after the start of the scan.

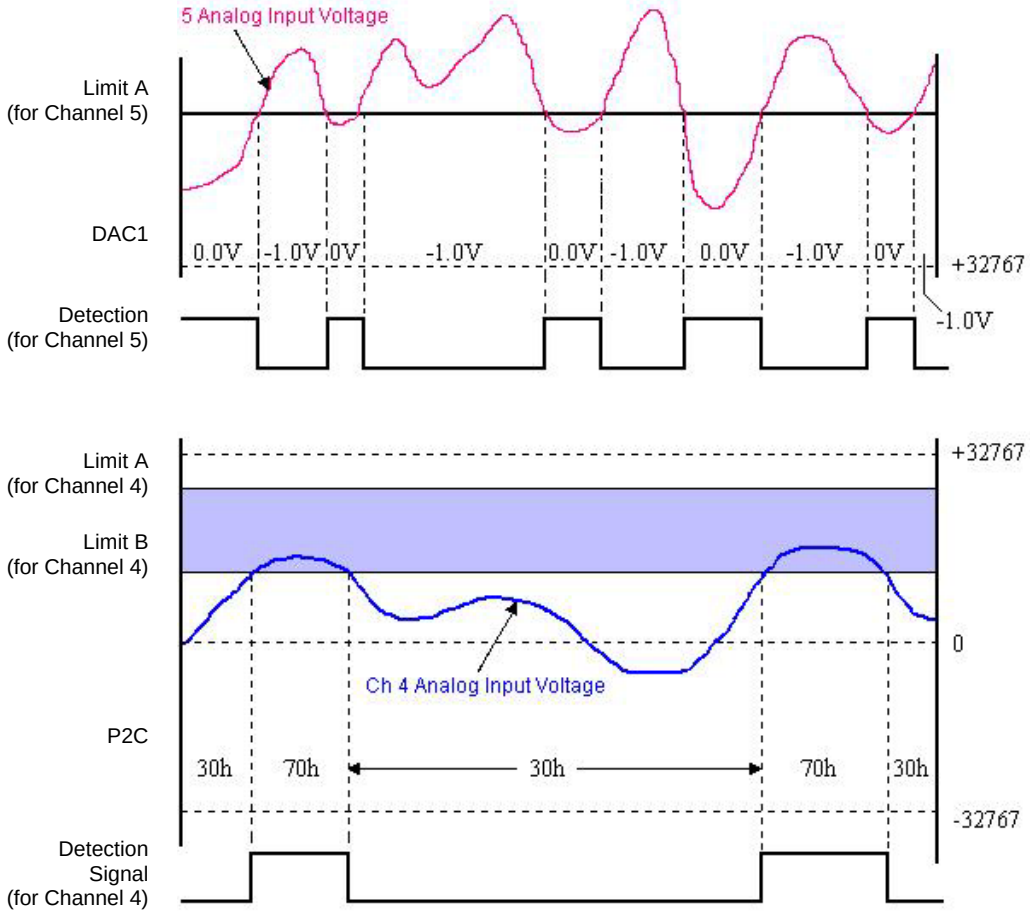
When using setpoints to control any of the DAC outputs, increased latencies may occur if attempting to stream data to DACs or pattern digital output at the same time. The increased latency can be as long as the period of the DAC pacer clock. For these reasons, avoid streaming outputs on any DAC or pattern digital output when using setpoints to control DACs.

Detection on an Analog Input, DAC and P2C Updates

Update Mode: Update on True and False
Criteria: Ch 5 example: Below Limit; Ch 4 example: Inside Window

In this example Channel 5 has been programmed with reference to one setpoint [Limit A], defining a low limit; and Channel 4 has been programmed with reference to two setpoints [Limits A and B] which define a window for that channel.

Channel	Condition	State of Detect Signal	Action
5	Below Limit A (for Channel 5)	True	When Channel 5 analog input voltage is below the limit A, update DAC1 with Output Value 0.0V.
		False	When the above stated condition is false, update DAC1 with the Output Value of *minus* 1.0V.
4	Within Window (Between Limit A and Limit B) for Channel 4	True	When Channel 4 analog input voltage is within the window, update P2C with 70h.
		False	When the above stated condition is false (Channel 4 analog input voltage is outside the window) update P2C with 30h.



Analog Inputs with Setpoints
Update on True and False

In the example [upper portion of the preceding figure], the setpoint placed on analog Channel 5 updated DAC1 with 0.0V. The update occurred when Channel 5's input was less than the setpoint (Limit A). When the value of Channel 5's input was above setpoint Limit A, the condition of <A was false and DAC1 was then updated with *minus*1.0V.

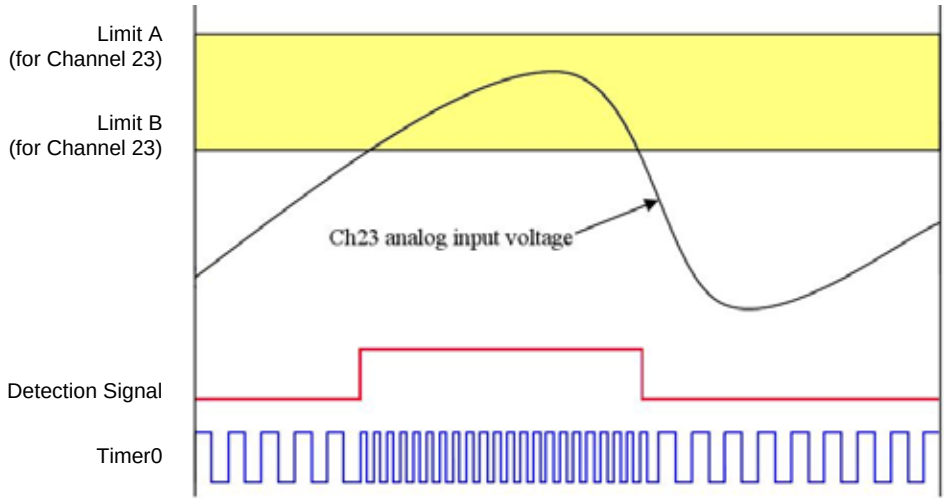
Control outputs can be programmed on each setpoint. Detection for Channel 4 could be used to update the P2C digital output port with one value (70h in the example) when the analog input voltage is within the shaded region and a different value when the analog input voltage is outside the shaded region (30h in the example).

Detection on an Analog Input, Timer Output Updates

Update Mode: Update on True and False
Criteria Used: Inside Window

The figure below shows how a setpoint can be used to update a timer output. Channel 23 is an analog input channel. It could be any analog input channel but in this example it happens to be on a PDQ30 expansion module. A setpoint is applied using *Update on True and False*, with a criteria of *inside-the-window*, where the signal value is inside the window when simultaneously less than Limit A but greater than Limit B.

Whenever the Channel 23 analog input voltage is inside the setpoint window (condition True), timer0 will be updated with one value; and whenever the Channel 23 analog input voltage is outside the setpoint window (condition False) timer0 will be updated with a second output value. An output value of 65535 will stop the timer.



Updating a Timer Output
Update on True and False

Using the Hysterisis Function

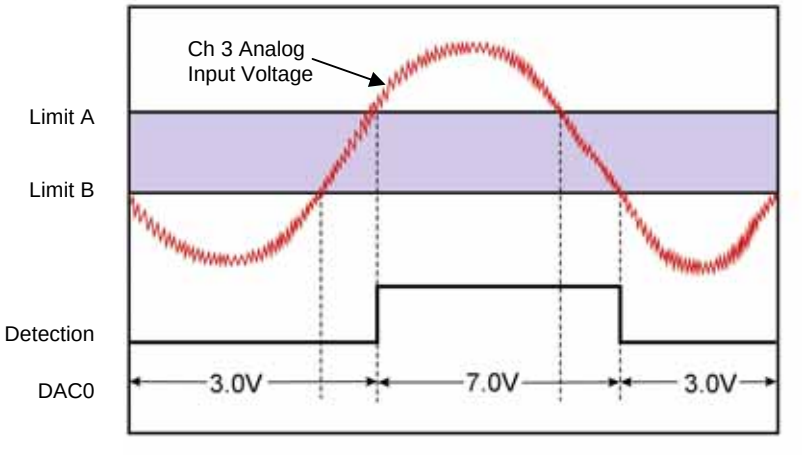
Update Mode: N/A, the Hysterisis option has a forced update built into the function
Criteria Used: window criteria for *above* and *below* the set limits

The figure below shows analog input Channel 3 with a setpoint which defines two 16-bit limits, Limit A (High) and Limit B (Low). These are being applied in the hysteresis mode and DAC Channel 0 will be accordingly.

In this example Channel 3's analog input voltage is being used to update DAC0 as follows:

- ***When outside the window, low*** (below Limit B) DAC0 is updated with 3.0V. This update will remain in effect until the analog input voltage goes above Limit A.
- ***When outside the window, high*** (above Limit A) DAC0 is updated with 7.0V. This update will remain in effect until the analog input signal falls below Limit B. At that time we are again outside the limit "low" and the update process repeats itself.

Hysteresis mode can also be done with P2C digital output port, or a timer output, instead of a DAC.



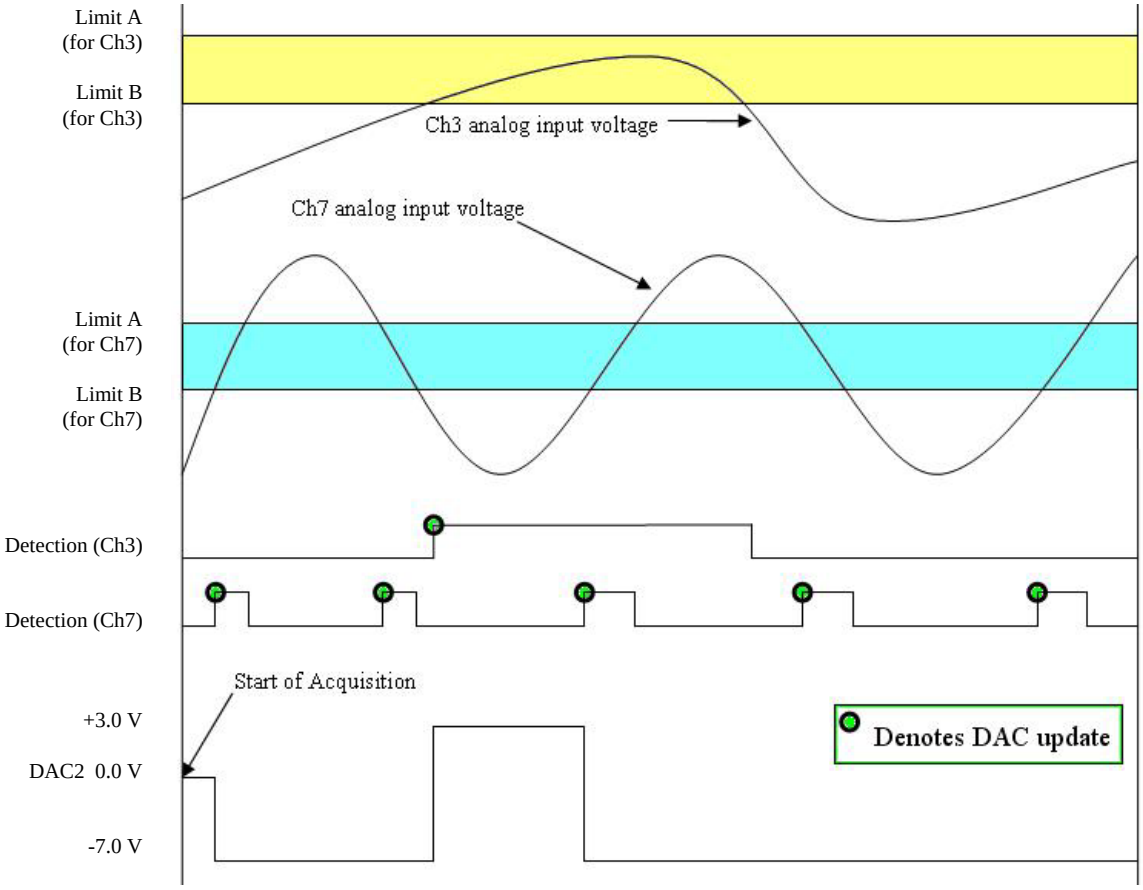
Channel 3 in Hysterisis Mode

Using Multiple Inputs to Control One DAC Output

Update Mode: Rising Edge, for each of 2 channels
Criteria Used: Inside Window, for each of 2 channels

The figure below shows how multiple inputs can update one output. In the following figure the DAC2 analog output is being updated. Analog input Channel 3 has an *inside-the-window* setpoint applied. Whenever Channel 3's input goes inside the programmed window, DAC2 will be updated with 3.0V.

Analog input Channel 7 also has an *inside-the-window* setpoint applied. Whenever Channel 7's input goes inside the programmed window, DAC2 will be updated with *minus* 7.0V.



Using Two Criteria to Control an Output*

* The update *on True Only* mode was selected and therefore the updates for DAC2 will only occur when the criteria is met. However, in the above figure we see that there are 2 setpoints acting on one DAC. We can also see that the two criteria can be met simultaneously. When both criteria are *True* at the same time, the DAC2 voltage will be associated with the criteria that has been most recently met.

The Setpoint Status Register

Regardless of which software application you are using with a DaqBoard/3000 Series device, a setpoint status register can be used to check the current state of the 16 possible setpoints. In the register, Setpoint 0 is the least significant bit and Setpoint 15 is the most significant bit. Each setpoint is assigned a value of 0 or 1. 0 indicates that the setpoint criteria is not met, i.e., the condition is false. 1 indicates that the criteria has been met, i.e., the condition is true. Related information is provided in the overview (pages 6-1 and 6-2.)

In the following example, the criteria for setpoints 0, 1, and 4 is satisfied (True); but the criteria for the other 13 setpoints has not been met.

Setpoint #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
True (1) False (0)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	<<< Most Significant Bit															Least Significant Bit >>>

From the above table we have 10011 binary, or 19 decimal, derived as follows:

Setpoint 0, having a True state, shows “1;” giving us decimal “1.”

Setpoint 1, having a True state, shows “1;” giving us decimal “2.”

Setpoint 4, having a True state, shows “1;” giving us decimal “16.”

For proper operation, the Setpoint Status Register must be the last channel in the scan list.

Notes

I/O Comparison Matrix					
Model DaqBoard/	**Analog Input Channels (ADC)**	**Analog Output Channels (DAC)**	**Digital I/O Channels**	**Counter Inputs**	**Timer Outputs**
3001USB	16SE / 8DE	4	24	4	2
3005USB	16SE / 8DE	0	24	4	2
3031USB	64SE / 32DE	4	24	4	2
3035USB	64SE / 32DE	0	24	4	2

General Specifications

Power Consumption (per board):

Model	**Power Consumption** (Typical)*
/3001USB	3000 mW
/3005USB	2000 mW
/3031USB	3400 mW
/3035USB	2400 mW

*An optional power adapter (TR-2) will be required if the USB port cannot supply adequate power. USB2 ports are, by USB2 standards, required to supply 2500 mW (nominal at 5V, 500 mA).

Power Output for DaqBoard/3000 USB

Output Power Supply Voltage	**Tolerance**	**Pin Numbers**	**Power Allowed when using USB Power**	**Power Allowed when using External Power**
+5 V	± 20%	P5-19; J7-22; J8-25	2 mA	10 mA
+13 V	± 10%	J8-1	1 mA	5 mA
- 13 V	± 10%	J8-2	1 mA	5 mA

Environment:
Operating Temperature: -30 to +70°C; Storage Temperature: -40 to +80°C
Relative Humidity: 0 to 95% non-condensing

Communications Speed: USB 2.0 high-speed mode (480 Mbps) if available, otherwise, USB1.1 full-speed mode (12 Mbps)

Acquisition Data Buffer: 1 MSample

Vibration: MIL STD 810E Category 1 and 10

Signal I/O Connectors: (see chapter 2 for pinouts)
68-pin standard "SCSI type III" female connector (P5); Four 40-pin headers (J5, J6, J7, J8), AMP# 2-103328-0

***Option* TB-100**: An optional TB-100 terminal board can be connected to the 3000USB board's 68-pin SCSI connector via a CA-G55, CA-56, or CA-56-6 cable. The TB-100 provides access to 16SE/8DE analog inputs, up to 4 analog outputs, 24 digital I/O, and all counter/timers. When using TB-100 with 3035 or 3031 models the remaining 48SE/24DE are accessed through 40-pin headers (see chapter 2 for details).

***Option* TB-101**: An optional TB-101 screw terminal board can be mounted directly to a 3000USB Series board, providing screw terminal connections for all of the board's I/O (see chapter 2 for details).

Temperature Measurement Connector: (see chapter 2 for pinouts)
4-channel TC screw-terminal block (TB7); Phoenix # MPT 0.5/9-2.54

External Power:
Connector: Switchcraft#RAPC-712
Power Range: 6 to 16 VDC (used when USB port supplies insufficient power, or when an independent power supply is desired)
Over-Voltage: 20 V for 10 seconds, max.

Physical Attributes:
Dimensions: 152.4 mm W x 150.62 mm D (6.0” x 5.93”)
Weight: 147 g (0.32 lbs)

Analog Inputs

Channels: 16 single-ended or 8 differential. Programmable on a per-channel basis as single-ended or differential. 4 differential channels can be assigned to thermocouples†

Over-Voltage Protection: ±30V without damage

Voltage Measurement Speed: 1 µs per channel

Ranges: Software or sequencer selectable on a per-channel basis.
±10V, ±5V, ±2V, ±1V, ±0.5V, ±0.2V, ±0.1V

Input Impedance: 10MΩ single-ended; 20MΩ differential

Total Harmonic Distortion: -80 db, typical for ±10V range, 1 kHz fundamental

Signal to Noise and Distortion: 72 db, typical for ±10V range, 1 kHz fundamental

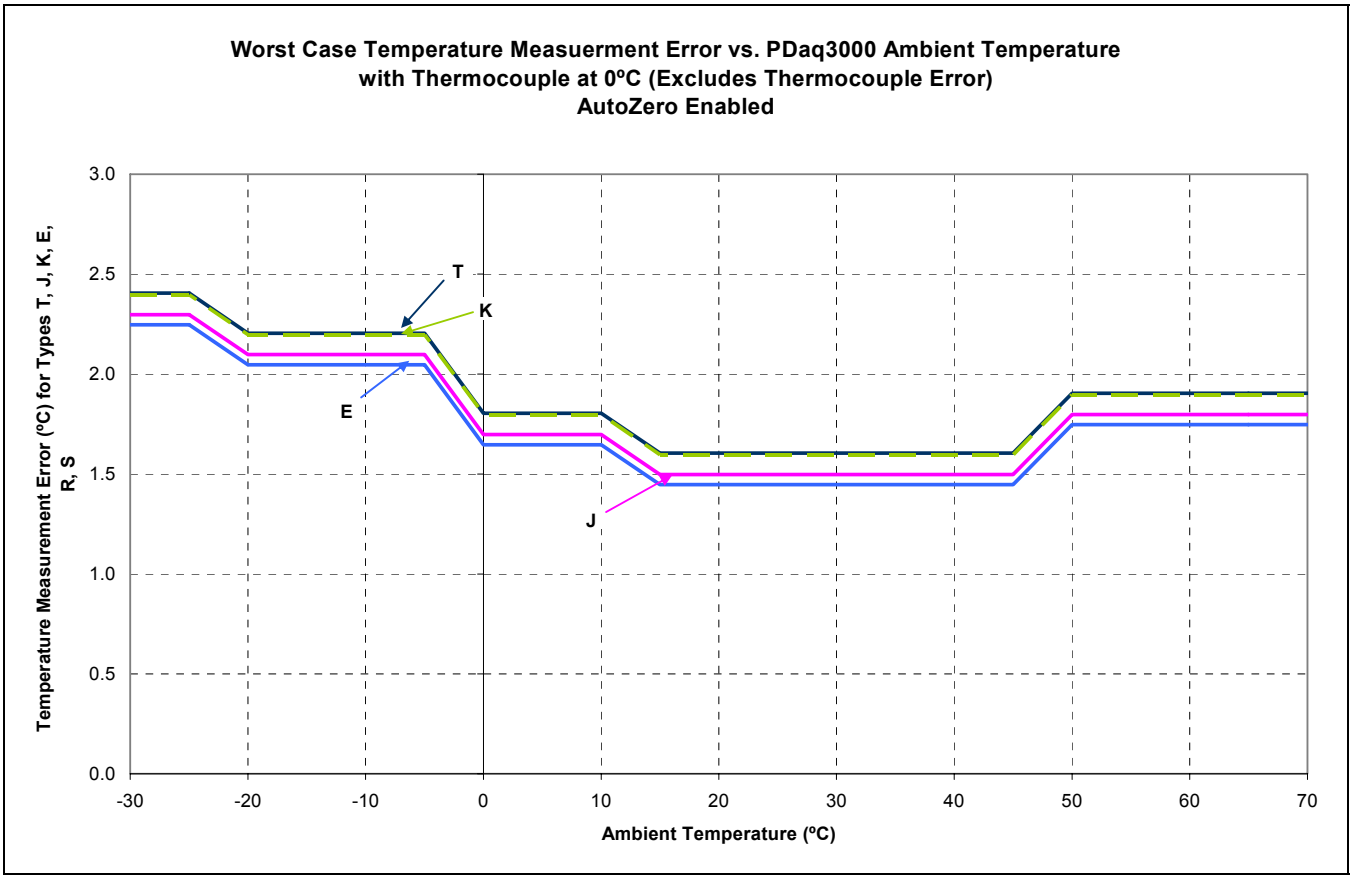
Bias Current: 40pA typical (0°C to 35°C)

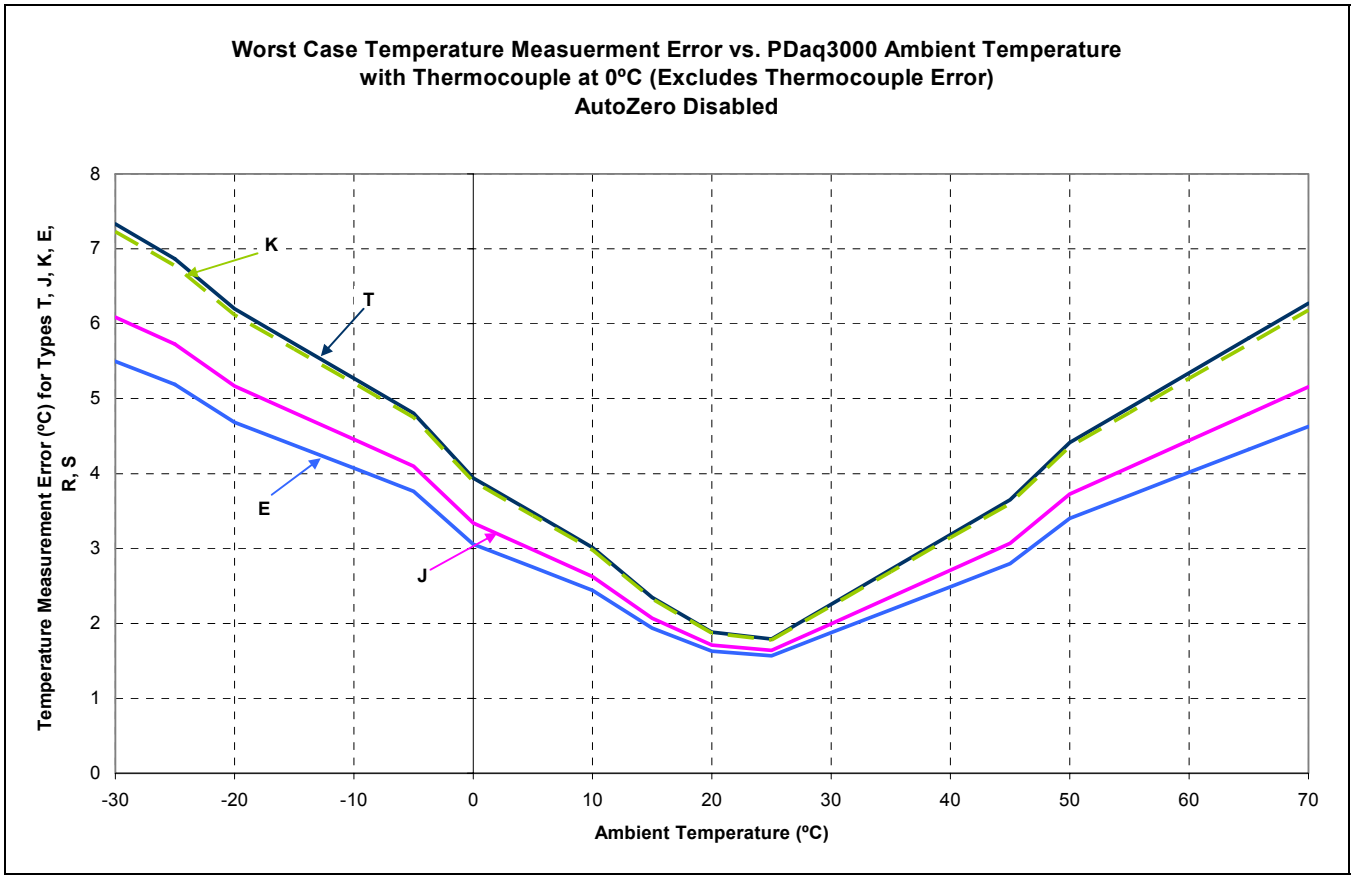
Crosstalk: -75 db typical DC to 60 Hz; -65 db typical @10 kHz

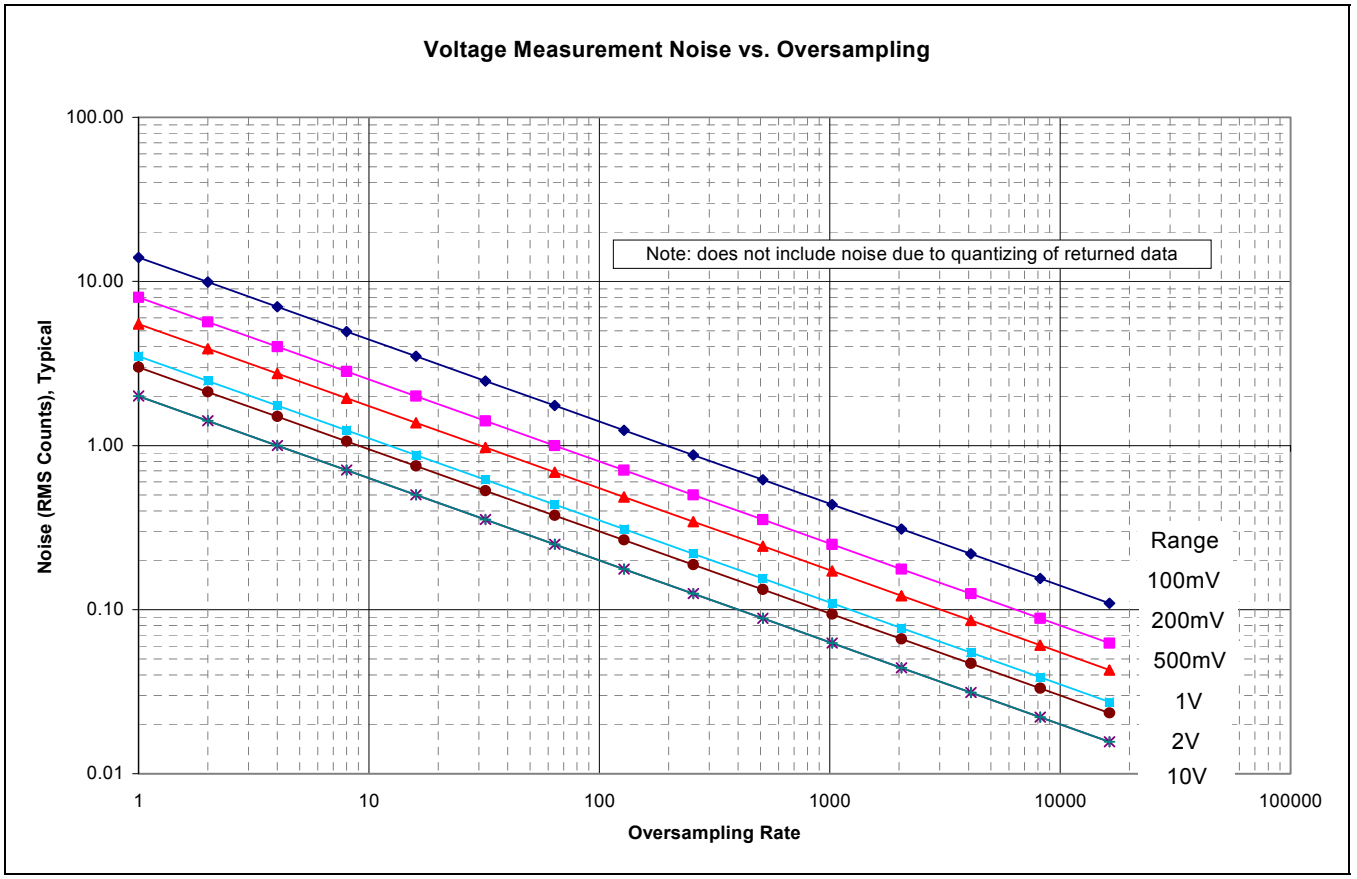
Common Mode Rejection: -70 dB typical DC to 1 kHz

Maximum Usable Input Voltage + Common Mode Voltage*	
Ranges	Maximum (CMV + V_{in})
0.5, 1, 2, 5, 10V	10.5V
0.1, 0.2V	2.1V

† DaqBoard/3035USB and DaqBoard/3031USB each support a total of 64SE (or 32 differential) channels.




Worst Case Temperature Measuerment Error vs. PDaq3000 Ambient Temperature
with Thermocouple at 0ºC (Excludes Thermocouple Error)
AutoZero Disabled
Temperature Measurement Error (ºC) for Types T, J, K, E, R, S
Ambient Temperature (ºC)
K
T
E
J
8
7
6
5
4
3
2
1
0
-30
-20
-10
0
10
20
30
40
50
60
70


Voltage Measurement Noise vs. Oversampling
Noise (RMS Counts), Typical
Oversampling Rate
Note: does not include noise due to quantizing of returned data
Range
100mV
200mV
500mV
1V
2V
10V
100.00
10.00
1.00
0.10
0.01
1
10
100
1000
10000
100000

Voltage Range*	Accuracy ±(% Reading + % Range) 23ºC ± 10°C, 1 year	Temperature Coefficient ± (ppm of Reading + ppm Range)/ºC -30ºC to 13°C and 33ºC to 70ºC	Noise** (cts RMS)
-10V to 10V	0.031% + 0.008%	14 + 8	2.0
-5V to 5V	0.031% + 0.009%	14 + 9	3.0
-2V to 2V	0.031% + 0.010%	14 + 10	2.0
-1V to 1V	0.031% + 0.02%	14 + 12	3.5
-500 mV to 500 mV	0.031% + 0.04%	14 + 18	5.5
-200 mV to 200 mV	0.036% + 0.05%	14 + 12	8.0
-100 mV to 100 mV	0.042% + 0.10%	14 + 18	14.0

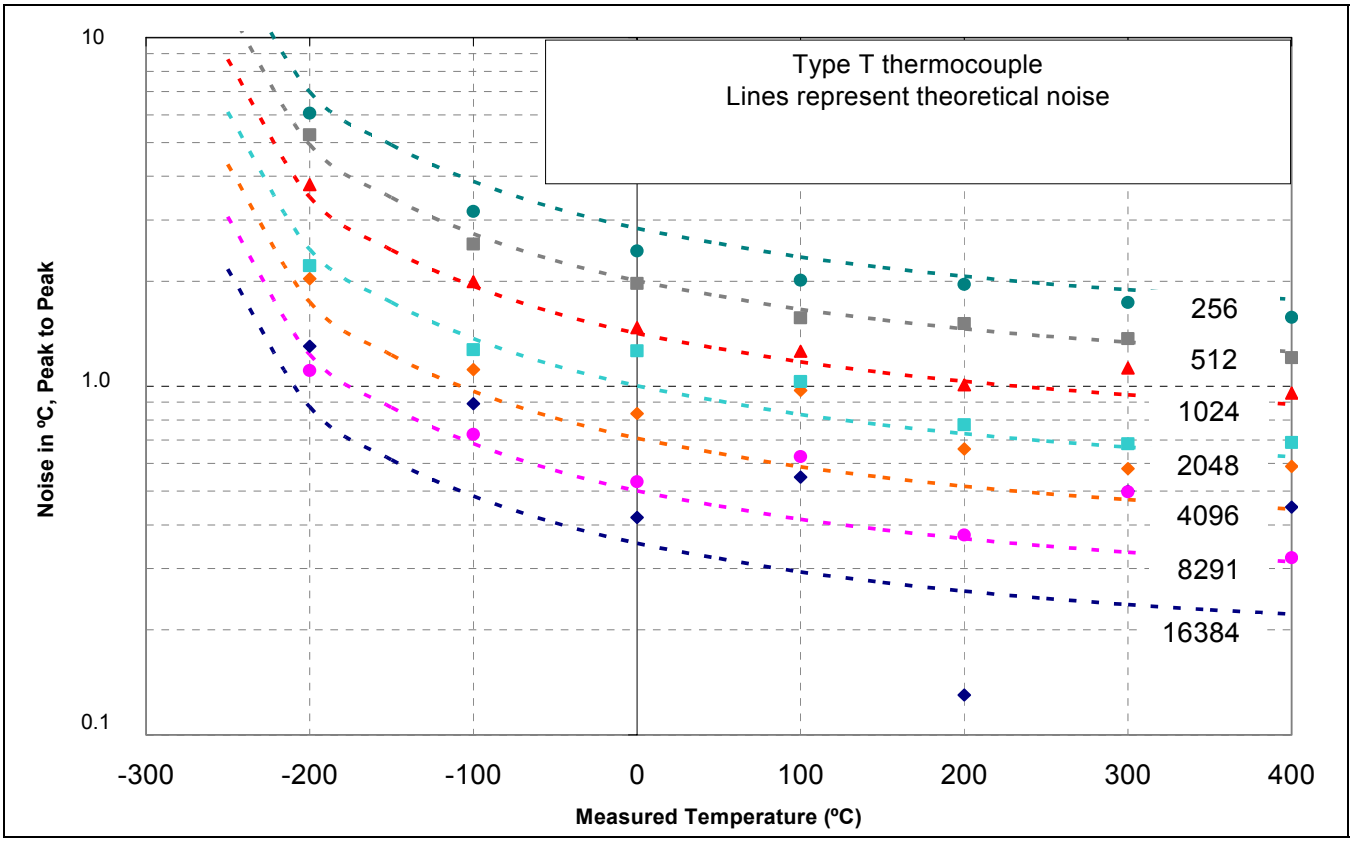
* Specifications assume differential input single-channel scan, 1-MHz scan rate, unfiltered, CMV=0.0V, 30 minute warm-up, exclusive of noise, range is -FS to +FS.

** Noise reflects 10,000 samples at 1-MHz, typical, differential short.

TC Types and Accuracy[1]

TC Type	Temperature Range (°C)	Accuracy (±°C)	Noise, Typical (±°C)
J	-200 to +760	1.7	0.2
K	-200 to +1200	1.8	0.2
T	-200 to +400	1.8	0.2
E	-270 to +650	1.7	0.2
R	-50 to +1768	4.8	1.5
S	-50 to +1768	4.7	1.5
N	-270 to +1300	2.7	0.3
B	+300 to +1400	3.0	1.0

[1] Assumes 16384 oversampling applied, CMV = 0.0V, 60 minute warm-up, still environment, and 25°C ambient temperature; excludes thermocouple error; TC_{IN} = 0°C for all types except B (1000 °C), TR-2 for External Power.



A/D Specifications

Type: Successive approximation
Resolution: 16 bit
Maximum Sample Rate: 1 MHz
Nonlinearity (Integral): ±2 LSB maximum
Nonlinearity (Differential): ±1 LSB maximum

Input Sequencer

Analog, digital and counter inputs can be scanned synchronously based on either an internal programmable timer, or an external clock source. Analog and digital outputs can be synchronized to either of these clocks.

Scan Clock Sources: 2

Note: The maximum scan clock rate is the inverse of the minimum scan period. The minimum scan period is equal to 1µs times the number of analog channels. If a scan contains only digital channels then the minimum scan period is 250 ns.

1. **Internal, programmable**
   Analog Channels from 1 µs to 19 hours in 20.83 ns steps
   Digital Channels and Counters from 250 ns to 19 hours in 20.83 ns steps

2. **External, TTL level input**
   Analog Channels down to 1 µs minimum
   Digital Channels and Counters down to 250 ns minimum

Programmable Parameters per Scan: Channel (random order), gain
Depth: 512 locations
On-board Channel-to-Channel Scan Rate:
Analog: 1 MHz maximum
Digital: 4 MHz if no analog channels are enabled, 1 MHz with analog channels enabled

External Acquisition Scan Clock Input

Maximum rate: 1.0 MHz
Clock Signal Range: Logical zero 0V to 0.8V; Logical one 2.4V to 5.0V
Minimum Pulse Width: 50 ns high, 50 ns low

Triggering

Trigger Sources: 7, individually selectable for starting and stopping an acquisition. Stop acquisition can occur on a different channel than start acquisition; stop acquisition can be triggered via modes 2, 4, 5, or 6 described below.

1. **Single-Channel Analog Hardware Trigger**: Any analog input channel can be software programmed as the analog trigger channel, including any of the analog expansion channels.
   Input Signal Range: -10 to +10V max
   Trigger Level: Programmable; 12-bit resolution
   Hysteresis: Programmable; 12-bit resolution
   Latency: 350 ns typical, 1.3 µs max
   Accuracy: ±0.5% of reading, ±2 mV offset
   Noise: 2 mV RMS

2. **Single-Channel Analog Software Trigger**: Any analog input channel, including any of the analog expansion channels, can be selected as the software trigger channel. If the trigger channel involves a calculation, such as temperature, then the driver automatically compensates for the delay required to obtain the reading, resulting in a maximum latency of one scan period.
   Input Signal Range: Anywhere within the range of the selected trigger channel
   Trigger Level: Programmable; 16-bit resolution, including "window triggering"
   Latency: One scan period max

3. **Single-Channel Digital Trigger**: A separate digital input is provided for digital triggering.
   Input Signal Range: -15V to +15V
   Trigger Level: TTL
   Minimum Pulse Width: 50 ns high; 50 ns low
   Latency: 100 ns typical, 1.1 µs max

4. **Digital Pattern Triggering**: 8 or 16-bit pattern triggering on any of the digital input ports. Programmable for trigger on equal, above, below, or within/outside of a window. Individual bits can be masked for "don't care" condition.
   Latency: One scan period max

5. **Counter/Totalizer Triggering**: Counter/totalizer inputs can trigger an acquisition. User can select to trigger on a frequency or on total counts that are equal, above, below, or within/outside of a window.
   Latency: One scan period max

6. **Software Triggering**: Trigger can be initiated under program control.

7. **Multi-Channel Triggering**: Up to 16 channels can be used to generate a trigger condition for any combination of analog, digital, or counter inputs. Multiple channels can either be combined in a logical "or" or "and" condition, with hysteresis programmable per channel. Maximum latency in this mode is one scan period.

Analog Outputs /3001USB and /3031USB models only

Analog output channels are updated synchronously relative to scanned inputs, and clocked from either an internal onboard clock, or an external clock source. Analog outputs can also be updated asynchronously, independent of any other scanning in the system. Streaming from disk or memory is supported, allowing continuous waveform outputs (limited only by available PC system resources).

Channels:

4 DAC channels (DAC0, DAC1, DAC2, DAC3)

Resolution: 16 bits

Data Buffer: PC based memory

Output Voltage Range: ±10V

Output Current: ±1 mA max; sourcing more current may require a TR-2 power adapter option.

Offset Error: ±0.0045V maximum

Digital Feedthrough: <10 mV when updated

DAC Analog Glitch: <12 mV typical at major carry

Gain Error: ±0.01%

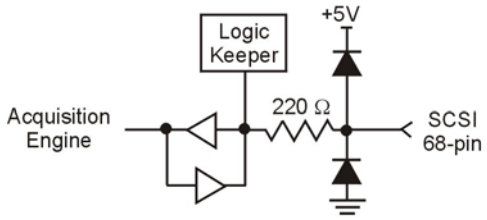
Update Rate: 1 MHz maximum, 19 hours minimum (no minimum with external clock); resolution: 20.83 ns.

Settling Time: 2 μs to rated accuracy

Clock Sources: 4 programmable

1. Onboard D/A clock, independent of scanning input clock
2. Onboard scanning input clock
3. External D/A input clock, independent of external scanning input clock
4. External scanning input clock

Digital I/O



One Digital I/O Channel, Typical

Channels: 24

Ports: 3 x 8-bit. Each port is programmable as input or output.

Input Scanning Modes: 2 programmable

1. Asynchronous, under program control at any time relative to input scanning
2. Synchronous with input scanning

Input Characteristics: 220 Ω series resistor, 20 pF to common

Logic Keeper Circuit: Holds the logic value to 0 or 1 when there is no external driver.

Input Protection: ±15 kV ESD clamp diodes parallel

Input Levels:

Low: 0 to 0.8V
High: +2.0V to +5.0V

Output Levels:

Low: < 0.8V
High: >2.0V

Output Characteristics: Output 1.0 mA per pin; ; sourcing more current may require a TR-2 power adapter option.

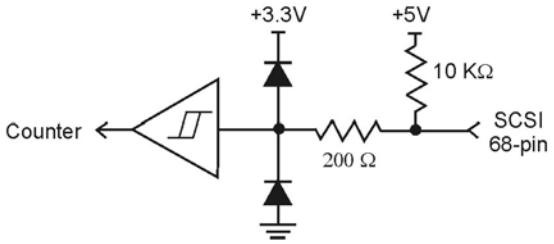
Sampling Rate: 4 MHz maximum

Update Rate: 4 MHz maximum; 19 hours minimum (no minimum with external clock); resolution: 20.83 ns.

Pattern Generation Output

Two of the 8-bit ports can be configured for 16-bit pattern generation. The pattern can be updated synchronously with an acquisition at up to 1 MHz.

Counters



One Counter Channel, Typical

Each of the four high-speed, 32-bit counter channels can be configured for counter, period, pulse width, time between edges, or multi-axis quadrature encoder modes. Counter inputs can be scanned synchronously along with analog and digital scanned inputs, based on an internal programmable timer, or an external clock source.

Channels: 4 x 32-bit

Input Frequency: 20 MHz maximum

Input Signal Range: -5V to +10V

Input Characteristics: 10 kΩ pull-up, 200Ω series resistor, ±15 kV ESD protection

Trigger Level: TTL

Minimum pulse width: 25 ns high, 25 ns low

Debounce Times: 16 selections from 500 ns to 25.5 ms. Positive or negative edge sensitive; glitch detect mode or debounce mode.

Time Base Accuracy: 50 ppm (0º to 50ºC)

Five Programmable Modes: Counter, Period, Pulsewidth, Timing, Encoder

1. Counter Mode Options: Totalize, Clear on Read, Rollover, Stop at all Fs, 16-bit or 32-bit, any other channel can gate or decrement the counter

2. Period Mode Options: Measure x1, x10, x100, or x1000 periods, 16-bit or 32-bit, 4 time bases to choose from (20.83 ns, 208.3 ns, 2.083 µs, 20.83 µs), any other channel can gate the period measurement

3. Pulsewidth Mode Options: 16-bit or 32-bit values, 4 time bases to choose from (20.83 ns, 208.3 ns, 2.083 µs, 20.83 µs), any other channel can gate the pulsewidth measurement

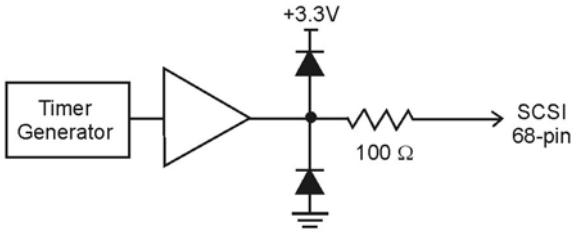
4. Timing Mode Options: 16-bit or 32-bit values, 4 time bases to choose from (20.83 ns, 208.3 ns, 2.083 µs, 20.83 µs)

5. Encoder Mode Options: x1, x2, x4 options, 16-bit or 32-bit values, Z-channel clearing of the counter, any other channel can gate the counter

Multi-axis Quadrature Encoder Inputs:

- 1 channel with A (phase), B (phase), and Z (index)
- 2 channel with A (phase) and B (phase)
- x1, x2, and x4 count modes
- Single-ended TTL

Frequency/Pulse Generators



One Timer Channel, Typical

Channels: 2 x 16-bit
Output Waveform: Square wave
Output Rate: 1 MHz base rate divided by 1 to 65535 (programmable)
High Level Output Voltage: 2.0V minimum @ -1.0 mA, 2.9V minimum @ -400 µA
Low Level Output Voltage: 0.4V maximum @ 400 µA

Software

DaqViewXL/Plus	DaqView add-on for seamless execution with Microsoft Excel's tool palette
DaqView/Pro	DaqView add-on includes all of the features of DaqViewXL/Plus, plus frequency-domain analysis
DASYLab	Icon-based data acquisition, graphics, control, and analysis software

Accessories and Cables

Termination Board (TB-100): Termination board with screw terminals for access to DaqBoard/3000USB Series I/O. The TB-100 terminal board connects to the DaqBoard/3000USB's 68-pin SCSI connector via a CA-G55, CA-56, or CA-56-6 cable (see chapter 2 for details).

Termination Board (TB-101) Termination board with screw terminals for access to DaqBoard/3000USB Series I/O; mounts directly to the 3000USB Series board, providing screw terminal connections for all of the board's I/O. Includes mounting stand-offs (see chapter 2 for details).

External Power Supply: TR-2: 120VAC to 9VDC, 1A

Rack Mount Kit for TB-100 (Rack3): Kit for mounting the TB-100 termination board to a rack.

DBK215 Termination Module: Includes 16 BNC connectors and internal screw-terminals. DBK215 connects to the DaqBoard's 68-pin SCSI connector via a CA-G55, CA-56, or CA-56-6 cable.

CA-G55: 68-conductor ribbon expansion cable. Can be used to connect a DaqBoard/3000 Series board to a TB-100 or DBK215. Cable length: 3 ft.

CA-G56: 68-conductor shielded expansion cable. Can be used to connect a DaqBoard/3000 Series board to a TB-100 or DBK215. Cable length: 3 ft.

CA-G56-6: 68-conductor shielded expansion cable. Can be used to connect a DaqBoard/3000 Series board to a TB-100 or DBK215. Cable length: 6 ft.

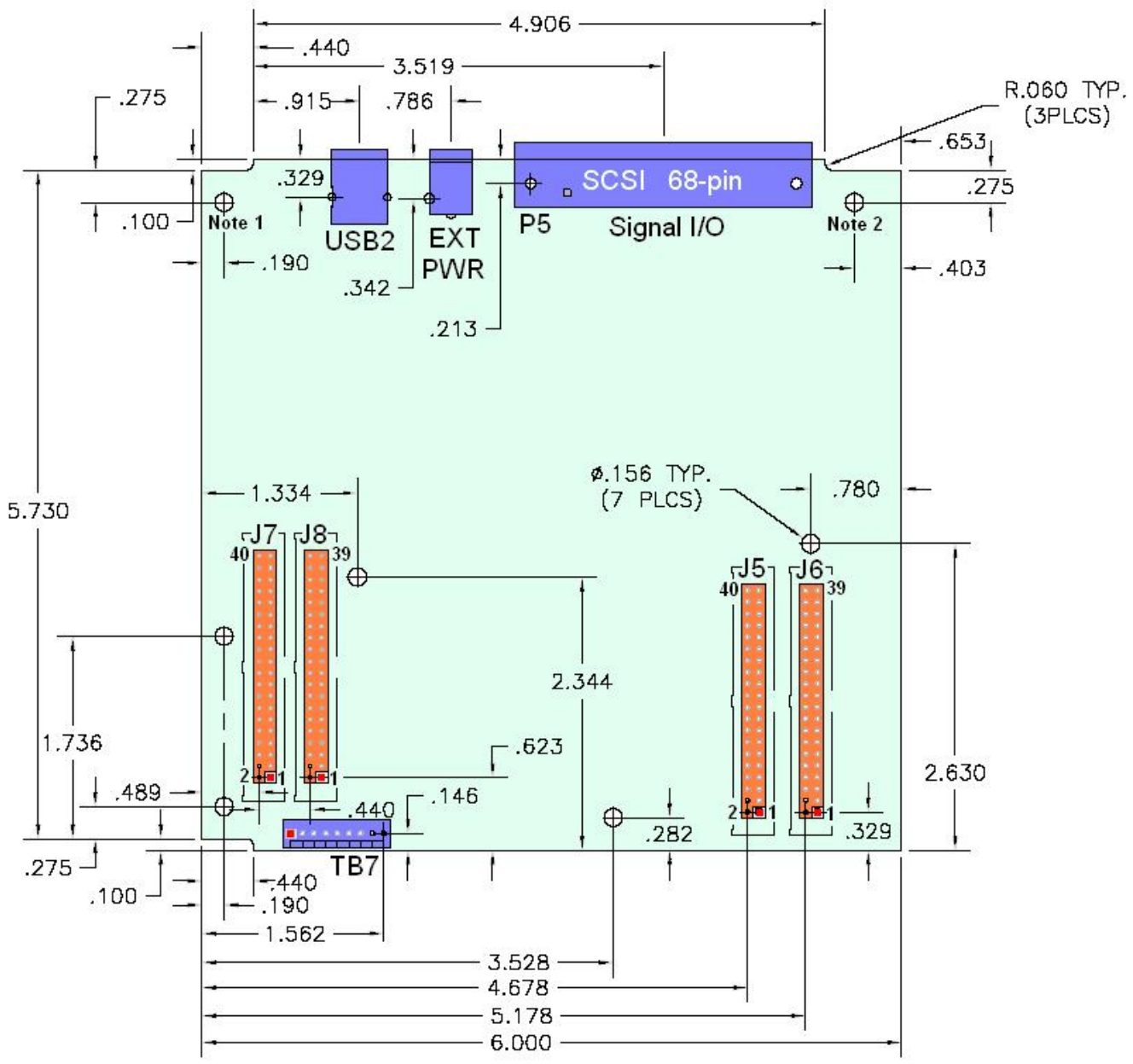
CA-179-1: USB Cable, 1 meter.

CA-179-3: USB Cable, 3 meters.

CA-179-5: USB Cable, 5 meters.

CA-248: Ribbon cable, 40-pin header to male 37-pin DSUB connector. 9 inches in length.

Dimensions



DaqBoard/3000USB Series – Board Dimensions

In general, all standoffs should be used to mount the board to a metal frame.

Note 1: The standoff at this location connects to the USB chassis for shunting electrostatic discharge.

Note 2: The standoff at this location connects to the DaqBoard/3000USB board's internal chassis plane for shunting electrostatic discharge.

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Appendix A — DBK215 16-Connector BNC Connection Module

With 68-Pin SCSI Adaptability for Analog I/O, Digital I/O, & Pulse/Frequency

Overview …… 1
Block Diagram …… 2
Connection Tips…… 3
System Examples …… 4
Using the Screw-Terminal Blocks …… 6
Adding RC Filter Networks …… 12
Specifications …… 14

DBK215 Front Panel
Upper Slot for Terminal Board Wiring Pass-Through
Lower section of 16 BNC Connectors

The DBK215 module is compatible with the following product series:

- DaqBoard/500 • DaqBoard/1000 • DaqBoard/3000 • DaqBoard/3000USB

Overview

DBK215 Rear Panel
Includes a 68-pin SCSI connector designated as P5.

The DBK215 module includes:

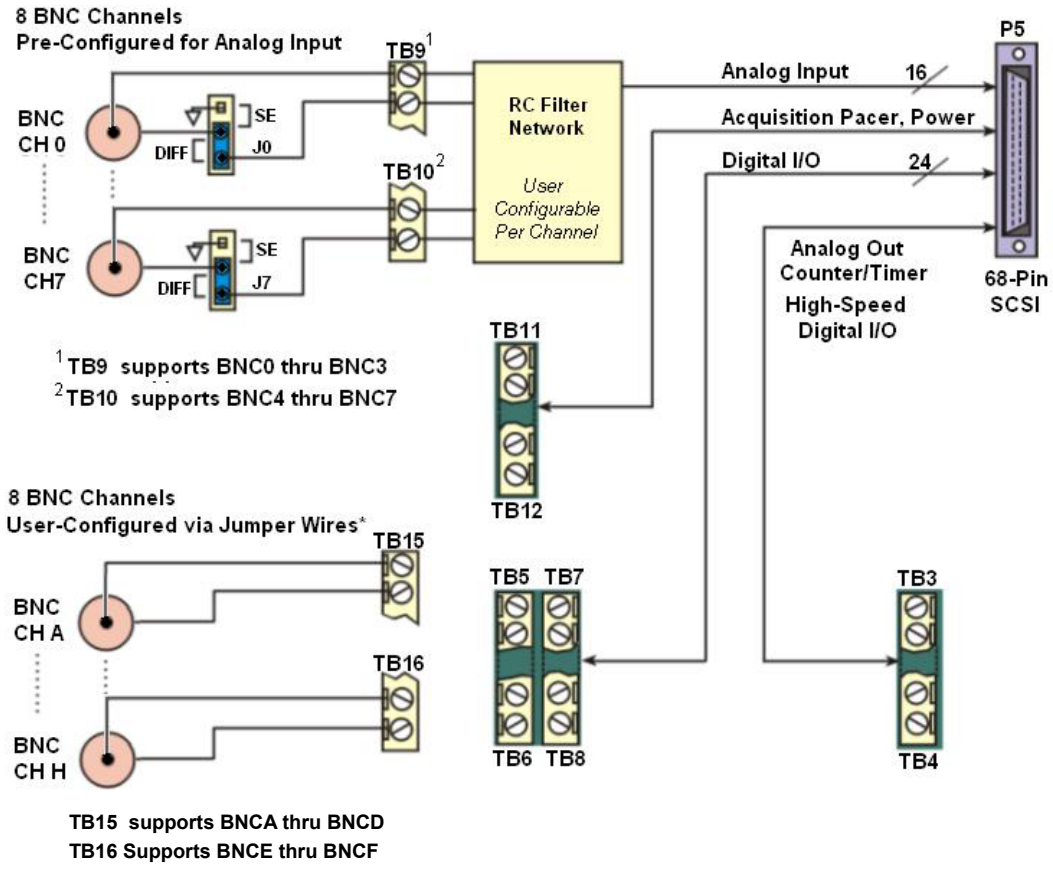
- BNC Access to 16 inputs or outputs (on front panel)
- on-board screw-terminal blocks*
- on-board socket locations for custom RC Filter networks*
- 68-pin SCSI connector (on rear panel)

* The top cover plate must be removed to access the terminal blocks and the RC filter network section of the board.

DBK215's SCSI connector (P5) connects to a second 68-pin SCSI connector on the board, i.e., DaqBoard/500, /1000, /3000, or /3000USB Series. Connection is made via a CA-G55, CA-G56, or CA-G56-6 cable. Cable descriptions are provided on page A-2.

The DBK215 provides BNC and screw-terminal access to all analog and digital I/O from the host data acquisition device. Related to the screw-terminals is a front panel slot for routing all I/O wiring.

Reference Note:
DBK215 is intended for DaqBoard/500, /1000, /3000, and /3000USB Series applications. Refer to the associated documentation as needed. For information concerning similar16 channel BNC connectivity/interface boards, designed for use with other products, refer to the DBK213 and DBK214 sections of the DBK Options manual (p/n 457-0905).



DBK215 Block Diagram

* Accessory Kit p/n 1139-0800 includes jumper wires and a screw driver.

Note that the 68-pin SCSI (P5) connector typically connects to a SCSI connector via a CA-G55, CA-G56, or CA-G56-6 cable.

- CA-G55 is a 3-foot long cable.
- CA-G56 is a 3-foot long shielded cable.
- CA-G56-6 is a 6-foot long shielded cable.

Connection Tips

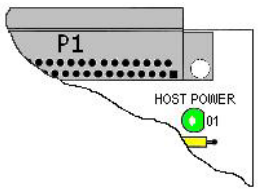
CAUTION

Turn off power to the host PC and externally connected equipment prior to connecting cables or signal lines to DBKs. Electric shock or damage to equipment can result even under low-voltage conditions.

Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.)

Use care to avoid touching board surfaces and onboard components. Only handle boards by their edges (or ORBs, if applicable). Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.

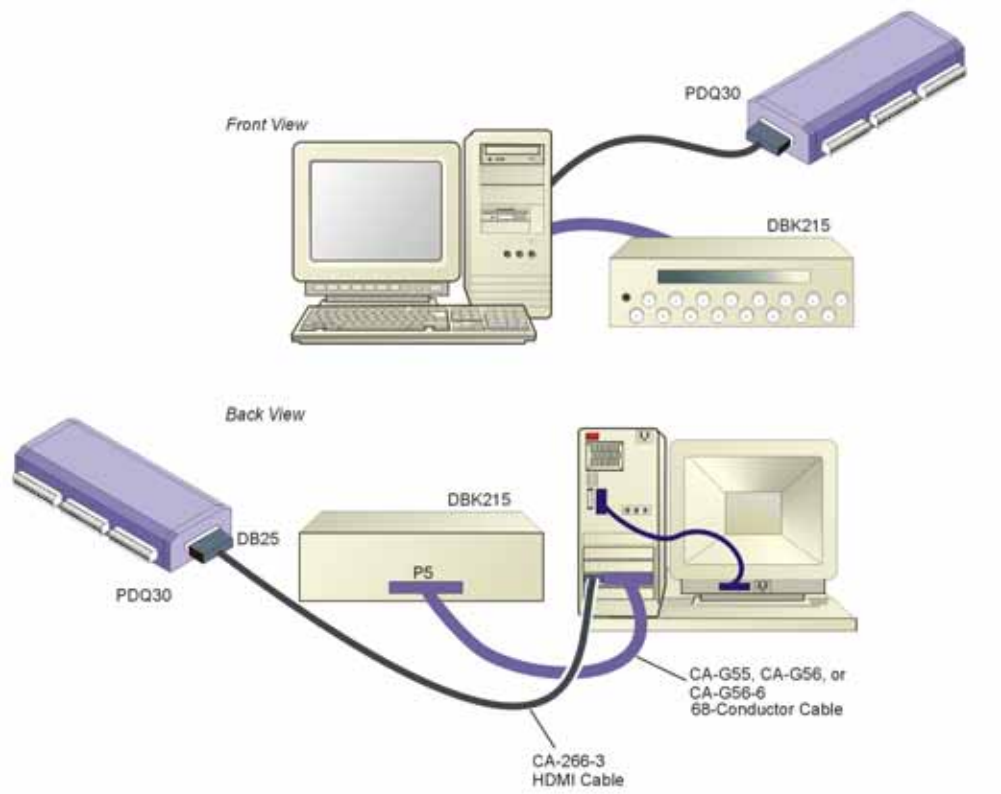
1. Ensure power is removed from all device(s) to be connected.
2. As soon as the DBK215 cover is removed, verify that the Host Power LED is "Off." See figure at right for location.
3. Observe ESD precautions when handling the board and making connections.
4. You do not need to remove the cover unless you need to access a terminal block, customize an RC filter network, or set a BNC channel to Single-Ended mode or to Differential mode (via Jumpers J0 through J7). Information regarding these tasks follows shortly.



Location of DBK215's Host Power LED

5. DBK215's 68-pin SCSI (P5) connector typically connects to a board's SCSI connector via a CA-G55, CA-G56, or CA-G56-6 cable.
   - CA-G55 is a 3-foot long cable.
   - CA-G56 is a 3-foot long shielded cable.
   - CA-G56-6 is a 6-foot long shielded cable.

Example 1: System with a DaqBoard/3000 Series Board (non-USB version)

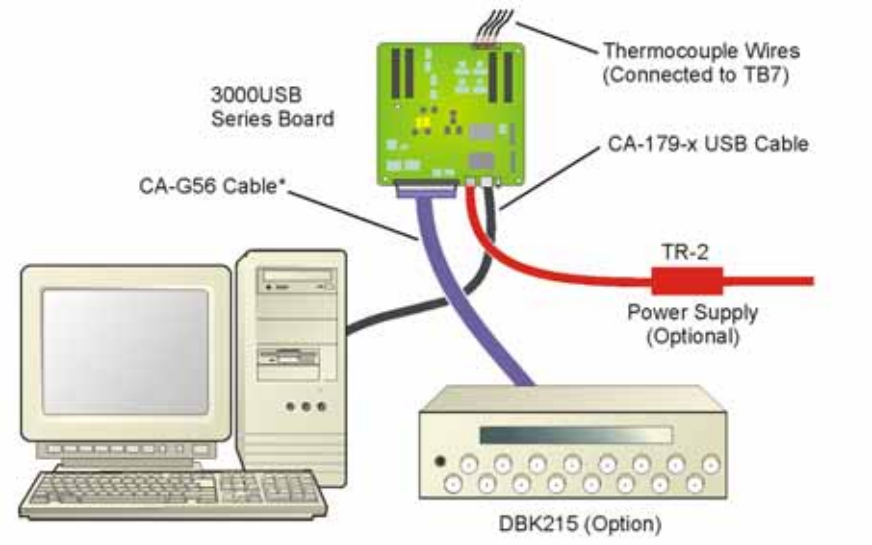


DBK215 and PDQ30 Connection to a DaqBoard/3000 Series Board

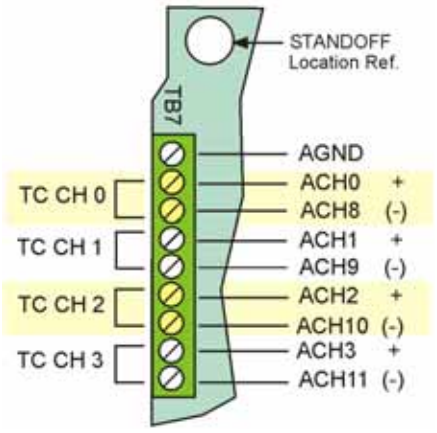
Notes regarding the above system example:

1) Any of three 68-conductor SCSI ribbon cables can be used to connect the DBK215 to the board's SCSI.
   - o CA-G55 is a 3-foot long cable.
   - o CA-G56 is a 3-foot long shielded cable.
   - o CA-G56-6 is a 6-foot long shielded cable.
2) Signal lines connect to the DBK215's front panel BNC connectors or to the internal screw-terminal board.
3) When signal lines are connected to the DBK215's terminal blocks (instead of the BNC connectors) the wires are routed out through the upper slot of the front panel.
4) The PDQ30 analog input expansion module can be connected to a /3000 Series board's HDMI connector. It does not apply to DaqBoard/500 Series or /1000 Series boards.

Example 2: System with a DaqBoard/3000USB Series Board



In this example a DBK215 BNC Module is connected to the 68-pin SCSI connector of a /3000USB Series board via a CA-G56 shielded cable. However, the use of other cables is possible as noted below. Four thermocouples are connected at the board's TB7 Terminal Block. This means that 8 analog channels [to obtain 4 differential TC channels] are required (see following figure). Redundant connections must be avoided. A TR-2 power supply is being used, and is connected to the board's external power connector.



WARNING !

Before connecting TC wires, ensure that the associated analog channels are not in use. Failure to do so could possibly cause equipment damage and/or personal injury.

The TB7 terminal block can be used to connect up to 4 thermocouples. The first TC channel makes use of Analog Channel 0 for its positive (+) lead and Analog Channel 8 for its negative (-) lead. The second TC channel uses analog Channels 1 and 9, and so on, as indicated in the pinout to the left.

Thermocouples should only be connected in differential mode. Appendix B includes additional information.

DaqBoard/3000USB Series devices do not have open thermocouple detection.

Note that a CA-179-x USB cable is being used to connect the /3000USB Series board to a USB port on the host PC.

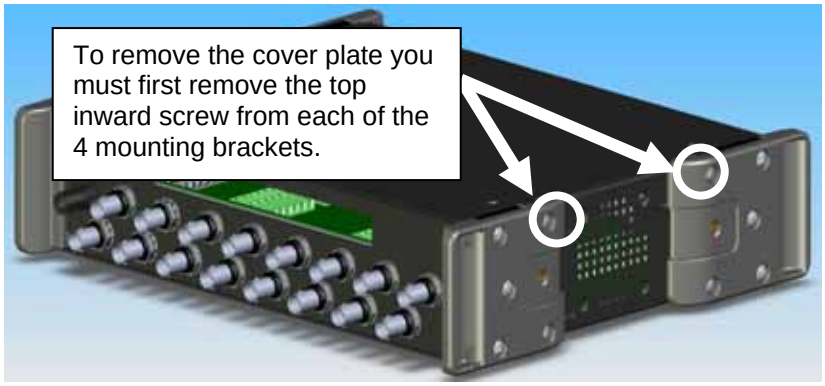
* Any of the following 68-conductor expansion cables can be used to connect the DBK215 module option the SCSI connector:

CA-G55	3 feet, ribbon cable.
CA-G56	3 feet, shielded expansion cable.
CA-G56-6	6 feet, shielded expansion cable.

Using the Screw-Terminal Blocks

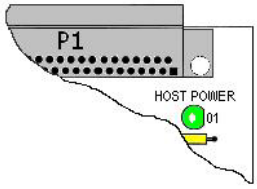
You must remove the DBK215 module's cover plate to access the screw terminal blocks. This is described in steps 1 and 2 below.

1. Remove the top inward screws from each of the 4 mounting brackets. See following figure.



The Cover Plate is Secured by 4 Srews [2 Screws per-side]

2. After the 4 screws have been removed, carefully remove the cover plate.
3. As soon as the DBK215 cover is removed, verify that the Host Power LED is "Off." See following figure for location.

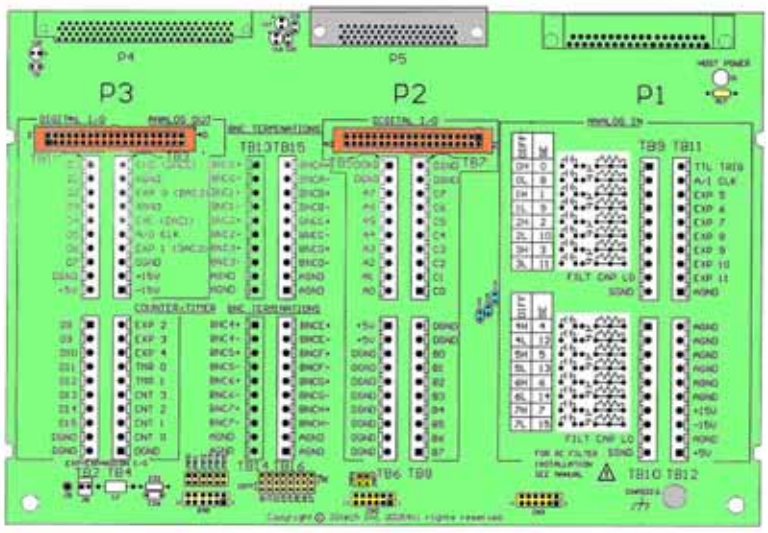


Host Power LED Location

4. Make the wiring connections to the terminals. Refer to the board's silkscreen and to the pin correlations on the next few pages.
5. Tighten the terminal block screws snug; but do not over-tighten.
6. After all terminal connections are made and verified correct, return the cover to the unit and secure in place with the 4 screws removed earlier. Tighten snug, but do not over-tighten.

In general, the following *terminal block-to-signal* relationships apply:

DBK215 Terminal Blocks	Used for . . .	Alternative
TB9 TB10	ANALOG INPUT	BNC 0 thru 7
TB11 TB12	ANALOG INPUT	N/A
TB5 TB6 TB7 TB8	DIGITAL I/O	N/A
TB13** TB14**	ANALOG INPUT BNC Channels 0 thru 7**	TB9,TB10
TB15 TB16 (Note 1)	USER CONFIGURABLEB NC Channels A thru H	(See Note 1)
TB1 TB2	-- Not Used---	N/A
TB3 TB4	PULSE/ FREQUENCY ANALOG OUTPUT	N/A



DBK215 Board

* P4 is used for connecting to DaqBoard/2000 Series devices.

** TB13 and TB14 are "virtual" terminal blocks which are routed in the printed circuit board to TB9 and TB10. The TB13 and TB14 silk-screened locations on the DBK215 board do not have physical screw terminal blocks.

Note 1: TB15 and TB16 are used for optional user-configured BNC connectors A through H. These connectors can be configured on a per-channel basis as Analog [Input or Output], Digital I/O, or Counter/Timer. When BNC A through H are used, the user must route wires from the "BNC routing terminal blocks" (TB15 and TB16) to the appropriate functional TB termination points.

Accessory Wire Kit, p/n 1139-0800 includes jumper wires and a screwdriver.

The following pages correlate the DBK215 terminal block connectors with the 68-pin SCSI connector.

Analog I/O Correlation to 68-pin SCSI

Also see “Correlation to BNC Terminations (TB13 and TB14) on page DBK215-11.”

TB9		Pin Number and Description	
DIFF	SE		
0H	0	68	CH 0 IN (Single-Ended Mode) / CH 0 HI IN (Differential Mode)
0L	8	34	CH 8 IN (Single-Ended Mode) / CH 0 LO IN (Differential Mode)
1H	1	33	CH 1 IN (Single-Ended Mode) / CH 1 HI IN (Differential Mode)
1L	9	66	CH 9 IN (Single-Ended Mode) / CH 1 LO IN (Differential Mode)
2H	2	65	CH 2 IN (Single-Ended Mode) / CH 2 HI IN (Differential Mode)
2L	10	31	CH 10 IN (Single-Ended Mode) / CH 2 LO IN (Differential Mode)
3H	3	30	CH 3 IN (Single-Ended Mode) / CH 3 HI IN (Differential Mode)
3L	11	63	CH 11 IN (Single-Ended Mode) / CH 3 LO IN (Differential Mode)
FILT CAP LO		**N/A**	For RC filter networks install a wire jumper between the relevant FILT CAP LO and AGND. Note that there is no association between FILT CAP LO and P4.
SGND		62	Signal Ground, Sense Common; reference ground, not for general use.

P1 – TB9
(Note 2)

TB10		Pin Number and Description	
DIFF	SE		
4H	4	28	CH 4 IN (Single-Ended Mode) / CH 4 HI IN (Differential Mode)
4L	12	61	CH 12 IN (Single-Ended Mode) / CH 4 LO IN (Differential Mode)
5H	5	60	CH 5 IN (Single-Ended Mode) / CH 5 HI IN (Differential Mode)
5L	13	26	CH 13 IN (Single-Ended Mode) / CH 5 LO IN (Differential Mode)
6H	6	25	CH 6 IN (Single-Ended Mode) / CH 6 HI IN (Differential Mode)
6L	14	58	CH 14 IN (Single-Ended Mode) / CH 6 LO IN (Differential Mode)
7H	7	57	CH 7 IN (Single-Ended Mode) / CH 7 HI IN (Differential Mode)
7L	15	23	CH 15 IN (Single-Ended Mode) / CH 7 LO IN (Differential Mode)
FILT CAP LO		**N/A**	For RC filter networks install a wire jumper between the relevant FILT CAP LO and AGND.
SGND		62	Signal Ground, Sense Common; reference ground, not for general use.

P1 – TB10
(Note 2)

TB11		
TTL TRIG	6	TTL Trigger, Digital IN, External TTL Trigger Input
A/I CLK	2	A/I Clock, External ADC Pacer Clock Input/ Internal ADC Pacer Clock Output
EXP 5	**N/A**	Expansion 5. Digital OUT, external GAIN select bit 1
EXP 6	**N/A**	Expansion 6. Digital OUT, external GAIN select bit 0
EXP 7	**N/A**	Expansion 7. Digital OUT, external ADDRESS, select bit 3
EXP 8	**N/A**	Expansion 8. Digital OUT, external ADDRESS, select bit 2
EXP 9	**N/A**	Expansion 9. Digital OUT, external ADDRESS, select bit 1
EXP 10	**N/A**	Expansion 10. Digital OUT, external ADDRESS, select bit 0
EXP 11	**N/A**	Expansion 11. Simultaneous Sample and Hold (SSH)
AGND	*	Analog Ground, Common

P1 – TB11

TB12		
AGND	*	Analog Ground, Common
AGND	*	Analog Ground, Common
AGND	*	Analog Ground, Common
AGND	*	Analog Ground, Common
AGND	*	Analog Ground, Common
AGND	*	Analog Ground, Common
+ 15 V	**N/A**	Expansion, +15 V Power
- 15 V	**N/A**	Expansion, -15 V Power
AGND	*	Common Ground
+ 5 V	19	Expansion, +5 V Power

P1 – TB12

*The following SCSI Pins connect to Analog Common: 24, 27, 29, 32, 55, 56, 59, 64, and 67.

Note 2: For TB9 and TB10, the filter network portion of the silkscreen is not shown. Instead, the DIFF and SE channel identifiers have been moved next to the screws for ease in identification.

Digital I/O Correlation to 68-pin SCSI

TB5	Pin Number and Description	
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
A7	49	Digital I/O: Port A, Bit 7
A6	15	Digital I/O: Port A, Bit 6
A5	50	Digital I/O: Port A, Bit 5
A4	16	Digital I/O: Port A, Bit 4
A3	51	Digital I/O: Port A, Bit 3
A2	17	Digital I/O: Port A, Bit 2
A1	52	Digital I/O: Port A, Bit 1
A0	18	Digital I/O: Port A, Bit 0

P2 – TB5

TB6	Pin Number and Description	
+5 V	19	Expansion +5 V Power
+5 V	19	Expansion +5 V Power
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common

P2 – TB6

TB7	Pin Number and Description	
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
C7	41	Digital I/O: Port C, Bit 7
C6	7	Digital I/O: Port C, Bit 6
C5	42	Digital I/O: Port C, Bit 5
C4	8	Digital I/O: Port C, Bit 4
C3	43	Digital I/O: Port C, Bit 3
C2	9	Digital I/O: Port C, Bit 2
C1	44	Digital I/O: Port C, Bit 1
C0	10	Digital I/O: Port C, Bit 0

P2 – TB7

TB8	Pin Number and Description	
DGND	**	Digital Ground, Common
DGND	**	Digital Ground, Common
B0	14	Digital I/O: Port B, Bit 0
B1	48	Digital I/O: Port B, Bit 1
B2	13	Digital I/O: Port B, Bit 2
B3	47	Digital I/O: Port B, Bit 3
B4	12	Digital I/O: Port B, Bit 4
B5	46	Digital I/O: Port B, Bit 5
B6	11	Digital I/O: Port B, Bit 6
B7	45	Digital I/O: Port B, Bit 7

P2 – TB8

* The following SCSI Pins connect to Analog Common: 24, 27, 29, 32, 55, 56, 59, 64, and 67.
** The following SCSI Pins connect to Digital Common: 35, 36, 40, and 53.

Pulse/Frequency Correlation to 68-pin SCSI

TB1	Pin Number and Description	
D0	**N/A**	P3 Digital Port Bit 0
D1	**N/A**	P3 Digital Port Bit 1
D2	**N/A**	P3 Digital Port Bit 2
D3	**N/A**	P3 Digital Port Bit 3 **TB1 is NOT USED**
D4	**N/A**	P3 Digital Port Bit 4
D5	**N/A**	P3 Digital Port Bit 5
D6	**N/A**	P3 Digital Port Bit 6
D7	**N/A**	P3 Digital Port Bit 7
DGND	**N/A**	Digital Ground, Common
+5V	**N/A**	Expansion, +5 Volt Power

P3 – TB1 (not used)

TB2	Pin Number and Description	
D8	**N/A**	P3 Digital Port Bit 8
D9	**N/A**	P3 Digital Port Bit 9
D10	**N/A**	P3 Digital Port Bit 10
D11	**N/A**	P3 Digital Port Bit 11 **TB2 is NOT USED**
D12	**N/A**	P3 Digital Port Bit 12
D13	**N/A**	P3 Digital Port Bit 13
D14	**N/A**	P3 Digital Port Bit 14
D15	**N/A**	P3 Digital Port Bit 15
DGND	**N/A**	Digital Ground, Common
DGND	**N/A**	Digital Ground, Common

P3 – TB2 (not used)

TB3	Pin Number and Description	
CH0 (DAC0)	22	Analog Out; Analog DAC 0 Output
AGND	*	Analog Ground, Common; intended for use with DACs
EXP 0 (DAC2)	**N/A**	Analog Out; Analog DAC 2 Output
AGND	*	Analog Ground, Common; intended for use with DACs
CH1 (DAC1)	21	Analog Out; Analog DAC 1 Output
A/O CLK	1	Analog Out Clock; External DAC Pacer Clock Input/ Internal DAC Pacer Clock Output
EXP 1 (DAC3)	**N/A**	Analog Out; Analog DAC 3 Output
DGND	**	Digital Ground, Common
+15 V	**N/A**	Expansion, + 15 VDC
-15 V	**N/A**	Expansion, -15 VDC

P3 – TB3

TB4	Pin Number and Description	
EXP 2	**N/A**	Reserved
EXP 3	**N/A**	Reserved
EXP 4	**N/A**	Reserved
TMR 0	3	P3 Timer 0 Output
TMR 1	37	P3, Timer 1 Output
CNT 3	38	P3 Counter 3 Input
CNT 2	4	P3 Counter 2 Input
CNT 1	39	P3 Counter 1 Input
CNT0	5	P3 Counter 0 Input
DGND	**	Digital Ground, Common

P3 – TB4

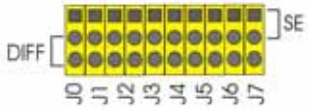
* The following SCSI Pins connect to Analog Common: 24, 27, 29, 32, 55, 56, 59, 64, and 67.
** The following SCSI Pins connect to Digital Common: 35, 36, 40, and 53.

Correlation to Analog Input BNC Terminations – BNC 0 through BNC 7

"Virtual" Terminal Blocks TB13 and TB14 for ANALOG INPUT connect to TB9 and TB10 through the printed circuit board.

TB13 ("Virtual" Terminal Block)			68-Pin SCSI Connector, Pin Number and Description		
BNC CH	**DIFF**	**SE**	**Pin**	**SE** = Single Ended ; **DIFF** = Differential	**Jumper Used**
BNC0+	0H	0	68	CH 0 IN (SE) / CH 0 HI IN (DIFF)	J0
BNC0-	0L	8	34	CH 8 IN (SE) / CH 0 LO IN (DIFF)	
BNC1+	1H	1	33	CH 1 IN (SE) / CH 1 HI IN (DIFF)	J1
BNC1-	1L	9	66	CH 9 IN (SE) / CH 1 LO IN (DIFF)	
BNC2+	2H	2	65	CH 2 IN (SE) / CH 2 HI IN (DIFF)	J2
BNC2-	2L	10	31	CH 10 IN (SE) / CH 2 LO IN (DIFF)	
BNC3+	3H	3	30	CH 3 IN (SE) / CH 3 HI IN (DIFF)	J3
BNC0+	3L	11	63	CH 11 IN (SE) / CH 3 LO IN (D DIFF)	
AGND	N/A	N/A	*	Analog Ground	N/A
AGND	N/A	N/A	*	Analog Ground	N/A

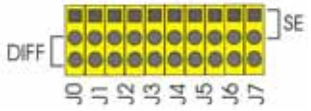
TB13 does not physically exist on DBK215. A silkscreen of TB13 is present as a visual aid to signal routing and configuration.



A header located beneath TB14 and TB16 is used to set the BNC channels to Single-Ended or to Differential. Simply place channel's 2-pin jumper in the appropriate position (SE or DIFF).

TB14 ("Virtual" Terminal Block)			68-Pin SCSI Connector, Pin Number and Description		
BNC CH	**DIFF**	**SE**	**Pin**	**SE** = Single Ended ; **DIFF** = Differential	**Jumper Used**
BNC4+	4H	4	28	CH 4 IN (SE) / CH 4 HI IN (DIFF)	J4
BNC4-	4L	12	61	CH 12 IN (SE) / CH 4 LO IN (DIFF)	
BNC5+	5H	5	60	CH 5 IN (SE) / CH 5 HI IN (DIFF)	J5
BNC5-	5L	13	26	CH 13 IN (SE) / CH 5 LO IN (DIFF)	
BNC6+	6H	6	25	CH 6 IN (SE) / CH 6 HI IN (DIFF)	J6
BNC6-	6L	14	58	CH 14 IN (SE) / CH 6 LO IN (DIFF)	
BNC7+	7H	7	57	CH 7 IN (SE) / CH 7 HI IN (DIFF)	J7
BNC7+	7L	15	23	CH 15 IN (SE) / CH 7 LO IN (DIFF)	
AGND	N/A	N/A	*	Analog Ground	N/A
AGND	N/A	N/A	*	Analog Ground	N/A

TB14 does not physically exist on DBK215. A silkscreen of TB14 is present as a visual aid to signal routing and configuration.



A header located beneath TB14 and TB16 is used to set the BNC channels to Single-Ended or to Differential. Simply place channel's 2-pin jumper in the appropriate position (SE or DIFF).

Correlation to Custom BNC Terminations – BNC A through BNC H

Pertains to Terminal Blocks TB15 and TB16 for Custom Configuration on a per-channel basis.

TB15 ("Routing" Terminal Block)	
BNC CH	**Description**
BNCA+	BNC channels A through D are configured on a per-channel basis by the user. TB15 is a routing terminal block used to connect BNCs (A thru D) to the desired signals, which are selected via a second DBK215 terminal block. For example: a user could run a wire from BNCA+ to TB4 screw terminal "TMR0" and BNCA- to TB4 DGND to create a BNC timer connection. Accessory Wire Kit, p/n 1139-0800 includes jumper wires and a screwdriver.
BNCA-	
BNCB+	
BNCB-	
BNCC+	
BNCC-	
BNCD+	
BNCD+	
AGND	Analog Ground *
AGND	Analog Ground *

TB15

TB16 ("Routing" Terminal Block)	
BNC CH	**Description**
BNCA+	BNC channels E through H are configured on a per-channel basis by the user. TB16 is a routing terminal block used to connect BNCs (E thru H) to the desired signals, which are selected via a second DBK215 terminal block. Customizing is as described for BNCA through BNCD above. Accessory Wire Kit, p/n 1139-0800 includes jumper wires and a screwdriver.
BNCA-	
BNCB+	
BNCB-	
BNCC+	
BNCC-	
BNCD+	
BNCD+	
AGND	Analog Ground *
AGND	Analog Ground *

TB16

* The following SCSI Pins connect to Analog Common: 24, 27, 29, 32, 55, 56, 59, 64, and 67.

Adding Resistor/Capacitor Filter Networks

WARNING

Disconnect the DBK215 from power and signal sources prior to installing capacitors or resistors.

CAUTION

Ensure wire strands do not short power supply connections to any terminal potential. Failure to do so could result in damage to equipment.

Do not exceed maximum allowable inputs (as listed in product specifications). There should never be more than 30 V with reference to analog ground (AGND) or earth ground.

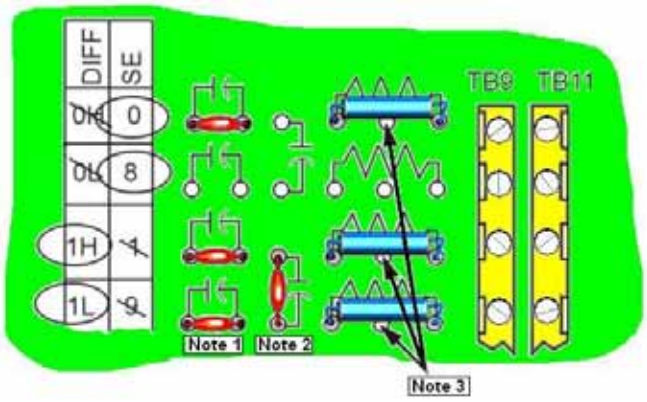
You must provide strain-relief (lead slack) to all leads leaving the module. Use tie-wraps [not included] to secure strain-relief.

Always connect the CHASSIS terminal to earth ground. This will maximize static protection.

If a channel is not associated with a DBK expansion option you can install a customized RC filter network to improve the signal-to noise ratio, assuming that an unacceptable level of noise exists. DBK215's internal board includes silk-screened sockets for installing RC filter networks. The following table contains values that are typical for RC filter network components.

Typical One-Pole Low Pass Filter Values for DBK215			
R	**C**	**f**	**f**
Ohms	**µF**	**Hertz (-3dB)**	**kHz (-3dB)**
510	1	312	0.31
510	0.47	664	0.66
510	0.22	1419	1.42
510	0.1	3122	3.12
510	0.047	6643	6.64
510	0.022	14192	14.19
510	0.01	31223	31.22
510	0.0047	66431	66.43
470	0.0033	102666	102.67

Do not use RC filters in conjunction with additional DBK expansion accessories.



An Example of Customer-Installed Capacitors and Filters for RC Networks

In this example Channels 0 and 8 are shown as *Single-Ended*. Channel 1 is *Differential*, i.e., using 1H and 1L (channel High and Low).

The following three notes pertain to the above figure.

Note 1: The 3 horizontal capacitors [as oriented in the illustration] are optional filter capacitors.

Note 2: The vertical capacitor [as oriented in the illustration] is an optional isolation capacitor used for the reduction of *Differential* noise. Such capacitor placement is not used in *Single-Ended* applications.

Note 3: If installing filter resistors, carefully drill out the indicated centers with a 1/16 inch drill-bit. Otherwise the resistor will be short-circuited.

Prior to installing RC components, review the previous Warning and Caution statements, then read over the following information regarding resistors and capacitors.

- **Do not use RC filters in conjunction with additional DBK expansion accessories.**
- **Prior to installing a resistor to the filter network you must drill a 1/16" hole through the center pinhole [beneath the board's silkscreen resistor symbol] as indicated in the preceding figure. Failure to do so will short-circuit the resistor.**
- **Do not drill holes on the board for channels, unless those channels are to receive a filter network (see preceding statement).**
- **Resistors should be ¼ watt, film-type with up to 5% tolerance. Do not use wire-wound resistor types.**
- **A resistor value of 510 Ω is recommended. Do not exceed 510 Ω.**
- **Capacitors used are to be of the film dielectric type (e.g., polycarbonate or NPO ceramic), above 0.001 µF.**
- **RECOMMENDED: For reduction of both *Common Mode Noise* and *Differential Mode Noise*, use one capacitor between Channel High and AGND; and use a second capacitor between Channel Low and AGND.**
- **For reduction of *Differential Noise* [when no reduction of *Common Mode Noise* is needed] position a capacitor across the respective Channel High and Channel Low.**
- **When in Differential Mode, using capacitors between Channel High, Channel Low, and AGND may cause a slight degradation of *wideband Common Mode rejection*.**
- **When making a RC filter network, always install a wire jumper between the relevant FILT CAP LO and AGND. FILT CAP LO terminals are located on TB9 and TB10.**

Specifications for DBK215

Operating Environment:

Temperature: -30°C to 70°C
Relative Humidity: 95% RH, non-condensing

Connectors:

P5: 68-Pin SCSI
Screw Terminals: 14 banks of 10-connector blocks
Wire Size: 12 TO 28 AWG

Dimensions:

285 mm W x 220 mm D x 45 mm H (11" x 8.5" x 2.7")

Weight:

1.36 kg (3 lbs)

Cables and Accessories:

Item Description	Part Number
Rack Mount Kit, p/n	RackDBK4
68-conductor expansion cables; mate with P5 (SCSI, 68-pin) connectors:	
3 ft., non-shielded	CA-G55
3 ft., shielded	CA-G56
6 ft., shielded	CA-G56-6
Accessory Wire Kit Includes jumper wires and a screwdriver.	1139-0800

Specifications are subject to change without notice.

Appendix B Signal Modes and System Noise

Signal Modes …… B-1
Connecting Thermocouples to Screw-Terminal Blocks …… B-2
Shielding …… B-3
TC Common Mode …… B-3
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Signal Modes

DaqBoard/3000USB units can make use of single-ended mode, or differential modes. Mode selection is made in software.

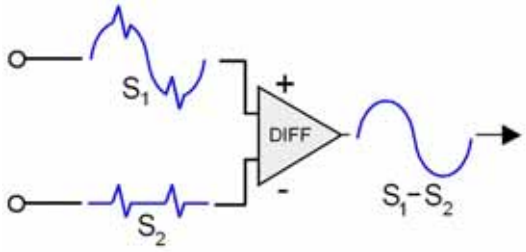
Single-ended mode refers to a mode, or circuit set-up, in which a voltage is measured between 1 signal line and common ground voltage (Analog Common, or A_{COM}). The measured voltage may be shared with other channels. The advantage of a single-ended *non-differential* mode [over differential mode] is that it provides for a higher channel count, for example: 16 channels instead of 8.

In DaqBoard/3000USB applications, thermocouples should never be connected *single-ended*. Doing so can result in noise and false readings.

Differential mode refers to a mode, or circuit set-up, in which a voltage is measured between two signal lines. The measured differential voltage is used for a single channel. An advantage of using differential inputs is that they reduce signal errors and the induction of noise resulting from ground current. The following illustration is an example of how noise is reduced, or canceled-out, when using the differential mode.

In the schematic, voltage signal S_2 is subtracted from signal S_1, resulting in the output signal shown. Noise spikes with *the same polarity, phase, and magnitude in each input signal* cancel out—resulting in a clean differential signal (S_1 - S_2).

In the schematic, signals S_1 and S_2 are shown in-phase; however, even if these signals were out of phase, the noise in each (indicated by jagged lines) would still have the same magnitude, phase, and polarity. For that reason, they would still cancel out.



Noise Reduction in Differential Mode

Differential signal hookups do not provide isolation or any kind of circuit protection.

Resolution: An analog-to-digital converter (ADC) converts an analog voltage to a digital number. The digital number represents the input voltage in discrete steps with finite resolution. ADC resolution is determined by the number of bits that represent the digital number. An *n*-bit ADC has a resolution of 1 part in 2^n. Thus, 12-bit and 16-bit resolutions are as follows:

- 12-bit resolution: 1 part in 4096 (2^{12}), corresponding to 2.44 mV in a 10 V range.
- 16-bit resolution: 1 part in 65,536 (2^{16}), corresponding to 0.153 mV in a 10 V range.

Connecting Thermocouples to Screw Terminal Blocks

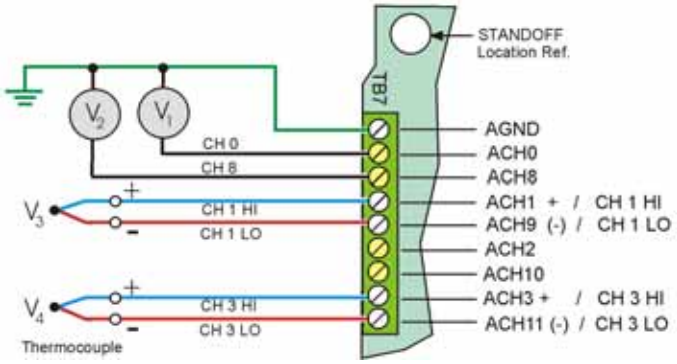
DaqBoard/3000USB Series boards can measure voltage channels in Single-Ended mode or channels of temperature in differential mode. You could, instead, mix signal types, for example have thermocouple and voltage channels connected.

In DaqBoard/3000USB Series applications, thermocouples must be connected *differentially*. Failure to do so will result in false readings.

DaqBoard/3000USB Series devices do not have open thermocouple detection.

Differential connection is made as follows:

(a) the red TC wire connects to the channel's Low (L) connector.
(b) the other color TC wire connects to the channel's High (H) connector.



Single-Ended and Differential Connections to TB7

The figure shows voltage Single-ended connections for V1 (Channel 0) and V2 (Channel 8); it also shows V3 and V4, each resulting from a different thermocouple. In the case of V3 and V4, *Differential* mode is being used. The HI (+) line from the thermocouple is shown connected to Channel 1 HI; and the LO (negative) side is connected to Channel 1 LO. Notice that Channel 1 LO is the same screw terminal connection that would be used for CH 9 Single-Ended. V4 is connected in a similar manner (see figure).

Thermocouple wire is standardized, color-coded, and polarized, as noted in the following table.

Thermocouple Standards				
T/C Type	(+) Lead to Channel High		(-) Lead to Channel Low	
J	White		Red	
K	Yellow		Red	
T	Blue		Red	
E	Violet		Red	
N28	Orange		Red	
N14	Orange		Red	
S	Black		Red	
R	Black		Red	
B	Gray		Red	

Thermocouples output very small voltages and long thermocouple leads can pickup a large amount of noise. If desired, noise reduction can be achieved through the use of shielded thermocouples and/or averaging.

You can minimize the effect of noise by:

(1) using shielded thermocouples *(see Shielding, page B-3)*

(2) averaging readings *(see Averaging, page B-4)*

(3) employing both of these practices.

Shielding

Using shielded TC wire with the shield connected to analog common will result in further noise reduction. DaqBoard/3000USB Series boards have one analog common screw-terminal on TB7 and have several analog common pins on the headers (see Chapter 2 pinouts). You can connect the shield of a shielded thermocouple to one of the analog commons. When this connection is made the shield at the other end of the thermocouple is to be left unconnected.

If a thermocouple shield is connected to the DaqBoard/3000USB Series board, leave the shield unconnected at the other end of the thermocouple. Connecting the shield to common at both ends will result in a ground loop.

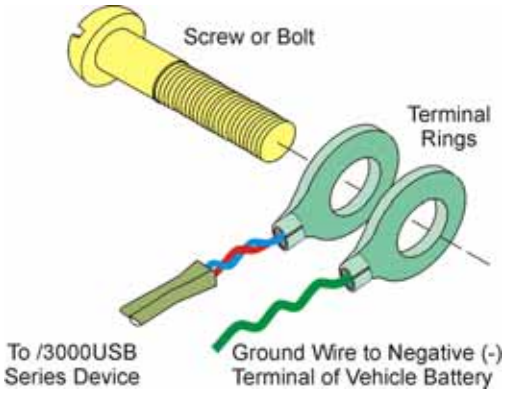
TC Common Mode

The maximum common-mode voltage for a DaqBoard/3000USB board is ±10 volts. Common-mode voltage is the DC or AC voltage signal that is applied equally to both sides of a differential input. Since thermocouples are measured using the 100 mV range, their maximum common mode voltage is ±2.1 volts.

If a thermocouple is connected directly to an engine component in a motor vehicle, at a potential that is over the maximum common-mode voltage, then very noisy or incorrect readings will be seen. Thermocouple connections that are made directly to an alternator or engine block may also result in high noise. Two methods of reducing noise are:

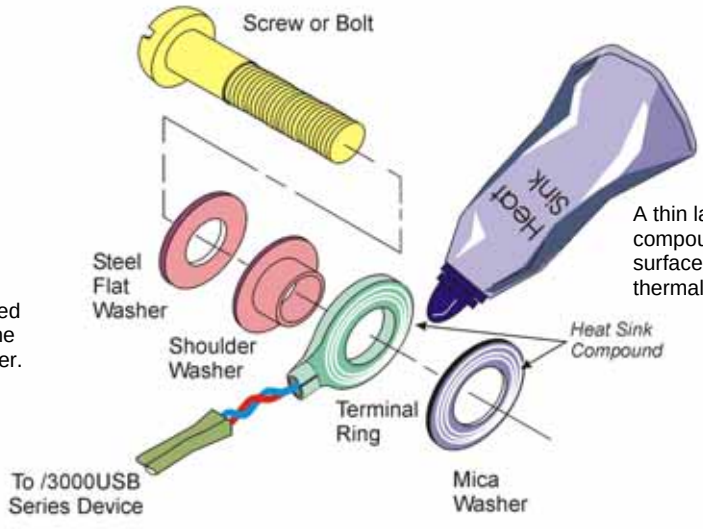
(a) Run a ground line from the screw (or bolt), as indicated in the first figure.

(b) Isolate the thermocouple leads with a set of washers, one of which is mica, as indicated in the second figure.



Running a Ground Wire to the Battery's Negative Terminal

The length of the shoulder washer's hub must not exceed the combined thickness of the terminal ring and mica washer.



A thin layer of heat-sink compound on the indicated surfaces will improve thermal conductivity.

Using a Washer Set and Heat Sink to Isolate the Thermocouple

Cold Junction Compensation Techniques

The DaqBoard/3000USB Series boards can measure up to 4 channels of temperature. Each board employs three thermistors to measure the junction temperature (at the TB7 terminal block) for each thermocouple connection. The thermistors are located just behind the terminal block. The actual junction is on the TB7 terminal block, and therefore there is some amount of error in each thermistor's ability to measure actual junction temperature.

DaqBoard/3000USB software compensates for the thermal error between the CJC thermistor temperature and the actual junction temperature at the terminal block. The units are profiled under controlled conditions (still air, 25°C, 60 minute warm-up, lying on a flat surface) and the thermal error is measured on a per channel basis. The per channel CJC temperature offsets are then stored inside the unit in non-volatile memory, along with the calibration constants.

Tips for Making Accurate Temperature Measurements

- Use as much oversampling as possible.
- Make sure the unit has been warmed up for at least 60 minutes, including thermocouple wires. This allows the unit to thermally stabilize so the CJC thermistors can accurately measure the junction at the terminal block.
- Make sure the surrounding environment is thermally stabilized and ideally around 20°C to 30°C. If the board's ambient temperature is changing due to a local heating or cooling source, then the TC junction temperature may be changing and the CJC thermistor will have a larger error.
- Use small diameter thermocouple wire that is "instrument grade." Small diameter thermocouple wire will have less effect on the thermocouple junction at the terminal block, as less heat will be transferred from the ambient environment to the junction.
- Make sure the board is mounted on a flat surface.
- If the unit will have a sustained ambient operating environment outside of the 20°C to 30°C range, consider autozero mode as a way to reduce the effects of offset drift. Performing a Y=MX+B adjustment at a desired ambient temperature can also be done. Make sure the unit has stabilized for at least 60 minutes.
- Be careful to avoid loading down the digital outputs or DAC outputs too heavily (>1 mA). Heavy load-down will cause significant heat generation inside the unit and increase the CJC thermistor error.

System Noise

Laboratory and industrial environments often have multiple sources of electrical noise. An AC power line is a source of 50/60 Hz noise. Heavy equipment (air conditioners, elevators, pumps, etc.) can be a source of noise, particularly when turned on and off. Local radio stations are a source of high-frequency noise, and computers and other electronic equipment can create noise in a multitude of frequency ranges. Thus, an absolute noise-free environment for data acquisition is not realistic. Fortunately, noise-reduction techniques such as averaging, filtering, differential voltage measurement, and shielding are available to reduce noise to an acceptable level.

Averaging

Certain acquisition programs apply *averaging* after several samples have been collected. Depending on the nature of the noise, averaging can reduce noise by the square root of the number of averaged samples. Although averaging can be effective, it suffers from several drawbacks. Noise in measurements only decreases as the square root of the number of measurements—reducing RMS noise significantly may require many samples. Thus, averaging is suited to low-speed applications that can provide many samples.

Note: Only random noise is reduced or eliminated by averaging. Averaging does not reduce or eliminate periodic signals.

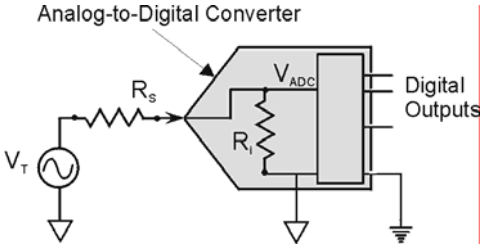
Analog Filtering

A filter is an analog circuit element that attenuates an incoming signal according to its frequency. A low-pass filter attenuates frequencies above the cutoff frequency. Conversely, a high-pass filter attenuates frequencies below the cutoff. As frequency increases beyond the cutoff point, the attenuation of a single-pole, low-pass filter increases slowly. Multi-pole filters provide greater attenuation beyond the cutoff frequency but may introduce phase (time delay) problems that could affect some applications.

Input and Source Impedance

As illustrated in the figure to the right, the input impedance (R_i) of an analog-to-digital converter combines with the transducer's source impedance (R_s) forming a voltage divider. This divider distorts the voltage being read at the analog-to-digital converter. The actual voltage read is represented by the equation:

$$\mathbf{V_{ADC} = V_T \times R_i / (R_s + R_i)}$$



The input impedance (R_i) of most ADCs is at least 1 MΩ; low source impedance (R_s) usually presents no problem. Some transducers, such as piezoelectric types, have high source impedance, and should therefore be used with a charge-sensitive amplifier of low output impedance. As described in the following paragraphs, multiplexing can greatly reduce the effective input impedance of an analog-to-digital converter.

Crosstalk

Crosstalk is a type of noise related to source impedance and capacitance, in which signals from one channel leak into an adjacent channel, resulting in interference or signal distortion. The impact of source impedance and stray capacitance can be estimated by using the following equation.

T = RC

Where **T** is the time constant, **R** is the source impedance, and **C** is the stray capacitance.

High source (transducer) impedance can be a problem in multiplexed A/D systems. When using more than 1 channel, the channel input signals are multiplexed into the A/D. The multiplexer samples one channel and then switches to the next channel. A high-impedance input interacts with the multiplexer's stray capacitance and causes crosstalk and inaccuracies in the A/D sample.

A solution to high source impedance in relation to multiplexers involves the use of buffers. The term buffer has several meanings; but in this case, *buffer* refers to an operational amplifier having high input impedance but very low output impedance. Placing such a buffer on each channel (between the transducer and the multiplexer) prevents the multiplexer's stray capacitance from combining with the high input impedance. This use of a buffer also stops transient signals from propagating backwards from the multiplexer to the transducer.

DaqBoard/3000USB Series boards do not have a buffer for each analog input channel, due to power restrictions. Crosstalk is particularly troublesome when measuring high amplitude signals (+/-10V) along with low level signals (+/- 100mV.) All temperature measurements are low level signals that use the +/- 100mV range of the boards.

If an acquisition's scan group includes both high level signals and low level signals, here are some tips on how to reduce the amount of crosstalk.

- Use as much oversampling as possible.
- Within the scan group, group high level signals together, group low level signals together
- Place a shorted channel in the scan group between the high level signals and the low level signals. The shorted channel should have the same gain as the last high level signal. This may allow for a faster scan rate with less oversampling.

Oversampling and Line Cycle Rejection

The DaqBoard/3000USB Series boards allow for oversampling and line cycle rejection to be done. When the units are put into oversampling mode, noise is reduced and ambient 60Hz or 50Hz pick up can be rejected. When enabled, oversampling is adjustable from 2 to 16384. The more oversampling that is done, the less noise present in the readings. Line cycle rejection is just another mode of oversampling where 16384; 8192; 4096; etc. consecutive samples are averaged over one line cycle of 50Hz or 60Hz.

When oversampling is employed it is done for all analog channels in the scan group: voltage, temperature, CJC, and autozero. Digital channels are not oversampled. Increasing the amount of oversampling will drastically decrease the maximum allowable scan rate. During acquisitions, the system controller reads each of the channel entries in the scan list and measures each channel according to the desired channel number and gain. If oversampling is enabled, the acquisition engine reads each of the channel entries in the scan list and takes multiple consecutive measurements without changing the channel or gain. All consecutive 16-bit measurements are averaged and then returned to the software.

In the case of line cycle rejection, the acquisition engine adjusts the conversion time of the ADC slightly so that 16384; 8192; 4096; etc. samples will fit inside one line cycle of 50 Hz (20ms) or 60Hz (16.666ms.)

Glossary

Acquisition — A collection of scans acquired at a specified rate as controlled by the sequencer.

Analog — A signal of varying voltage or current that communicates data.

Analog-to-Digital Converter (ADC) — A circuit or device that converts analog values into digital values, such as binary bits, for use in digital computer processing.

API — Application Program Interface. The interface program within the Daq system's driver that includes function calls specific to Daq hardware and can be used with user-written programs (several languages supported).

Bipolar — A range of analog signals with positive and negative values (e.g., -5 to +5 V); see *unipolar*.

Buffer — *Buffer* refers to a circuit or device that allows a signal to pass through it, while providing isolation, or another function, without altering the signal. *Buffer* usually refers to:

(a) A device or circuit that allows for the temporary storage of data during data transfers. Such storage can compensate for differences in data flow rates. In a FIFO (First In - First Out) buffer, the data that is stored first is also the first data to leave the buffer.

(b) A follower stage used to drive a number of gates without overloading the preceding stage.

(c) An amplifier which accepts high source impedance input and results in low source impedance output (effectively, an impedance buffer).

Buffer Amplifier — An amplifier used primarily to match two different impedance points, and isolate one stage from a succeeding stage in order to prevent an undesirable interaction between the two stages. (Also see, *Buffer*).

Channel — In reference to Daq devices, *channel* simply refers to a single *input*, or *output* entity.

In a broader sense, an *input channel* is a signal path between the transducer at the point of measurement and the data acquisition system. A channel can go through various stages (buffers, multiplexers, or signal conditioning amplifiers and filters). Input channels are periodically sampled for readings.

An *output channel* from a device can be digital or analog. Outputs can vary in a programmed way in response to an input channel signal.

Common mode — Common mode pertains to signals that are identical in amplitude and duration; also can be used in reference to signal components.

Common mode voltage — Common mode voltage refers to a voltage magnitude (referenced to a common point) that is shared by two or more signals. *Example*: referenced to common, Signal 1 is +5 VDC and Signal 2 is +6 VDC. The common mode voltage for the two signals is +5.5 VDC [(5 + 6)/2].

Crosstalk — An undesired transfer of signals between systems or system components. Crosstalk causes signal interference, more commonly referred to as *noise*.

Digital — A digital signal is one of discrete value, in contrast to a varying signal. Combinations of binary digits (0s and 1s) represent digital data.

Digital-to-Analog Converter (DAC) — A circuit or device that converts digital values (binary bits), into analog signals.

DIP switch — A DIP switch is a group of miniature switches in a small *Dual In-line Package* (DIP). Typically, users set these switches to configure their particular application.

Differential mode — The differential mode measures a voltage between 2 signal lines for a single channel. (Also see *single-ended mode*).

Differential mode voltage	Differential mode voltage refers to a voltage difference between two signals that are referenced to a common point. Example: Signal 1 is +5 VDC referenced to common. Signal 2 is +6 VDC referenced to common. If the +5 VDC signal is used as the reference, the differential mode voltage is +1 VDC (+ 6 VDC - +5 VDC = +1 VDC). If the +6 VDC signal is used as the reference, the differential mode voltage is -1 VDC (+ 5 VDC - +6 VDC = -1 VDC).
ESD	Electrostatic discharge (ESD) is the transfer of an electrostatic charge between bodies having different electrostatic potentials. This transfer occurs during direct contact of the bodies, or when induced by an electrostatic field. ESD energy can damage an integrated circuit (IC).
Excitation	Some transducers [e.g. strain gages, thermistors, and resistance temperature detectors (RTDs)] require a known voltage or current. Typically, the variation of this signal through the transducer corresponds to the condition measured.
Gain	The degree to which an input signal is amplified (or attenuated) to allow greater accuracy and resolution; can be expressed as ×n or ±dB.
Isolation	The arrangement or operation of a circuit so that signals from another circuit or device do not affect the *isolated* circuit. In reference to Daq devices, *isolation* usually refers to a separation of the direct link between the signal source and the analog-to-digital converter (ADC). Isolation is necessary when measuring high common-mode voltage.
Linearization	Some transducers produce a voltage in linear proportion to the condition measured. Other transducers (e.g., thermocouples) have a nonlinear response. To convert nonlinear signals into accurate readings requires software to calibrate several points in the range used and then interpolate values between these points.
Multiplexer (MUX)	A device that collects signals from several inputs and outputs them on a single channel.
Range	For the purposes of calculating accuracy, range is equal to the full dynamic input voltage. For example, the full-scale range is 20V for the -10 to +10V range.
Sample (reading)	The value of a signal on a channel at an instant in time. When triggered, the ADC reads the channel and converts the sampled value into a 12- or 16-bit value.
Scan	A series of measurements across a pre-selected sequence of channels.
Sequencer	A programmable device that manages channels and channel-specific settings.
Simultaneous Sample-and-Hold	An operation that gathers samples from multiple channels at the same instant and holds these values until all are sequentially converted to digital values.
Single-ended mode	The single-ended mode measures a voltage between a signal line and a common reference that may be shared with other channels. (Also see *differential mode*).
Trigger	An event to start a scan or mark an instant during an acquisition. The event can be defined in various ways; e.g., a TTL signal, a specified voltage level in a monitored channel, a button manually or mechanically engaged, a software command, etc. Some applications may use pre- and post-triggers to gather data around an instant or based on signal counts.
TTL	Transistor-Transistor Logic (TTL) is a circuit in which a multiple-emitter transistor has replaced the multiple diode cluster (of the diode-transistor logic circuit); typically used to communicate logic signals at 5 V.
Unipolar	A range of analog signals that is always zero or positive (e.g., 0 to 10 V). Evaluating a signal in the right range (unipolar or bipolar) allows greater resolution by using the full-range of the corresponding digital value. See *bipolar.*